THE ENGINEER

NOVEMBER 25, 1960 28 ESSEX STREET, STRAND, LONDON, W.C.2 TWO SHILLINGS

On Electric Locomotives and Multiple-unit stock

BRITISH RAILWAYS, SOUTHERN REGION

British Timken have received orders for Timken tapered roller bearing axleboxes and for traction motor suspension units for use on the East Kent electrification scheme.

The 2,500 H.P. electric locomotive illustrated above is one of a number equipped with Timken axleboxes. This design of axlebox, fitted with two Timken bearings, forms part of the S.L.M. bogie suspension system.

A generally similar design of Timken axlebox is employed in the bogie suspension system of the S.L.M.-built diesel electric locomotives in service on the Swiss Federal Railways, for which repeat orders have been received.

Traction motor suspension units incorporating Timken bearings are fitted to the 'English Electric' motors applied to the multiple-unit stock.

Timken bearings are also being used extensively on the new A.C. electric multiple-unit stock.

British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

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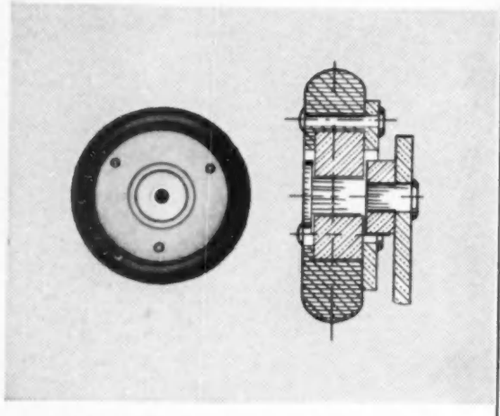

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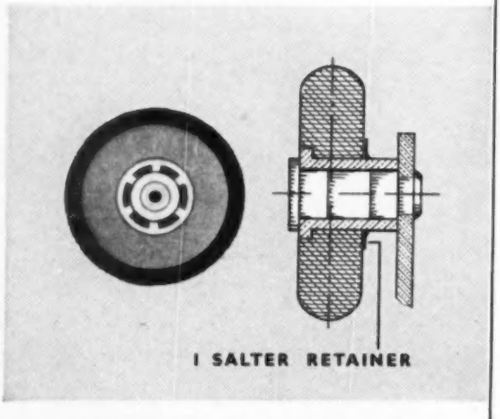

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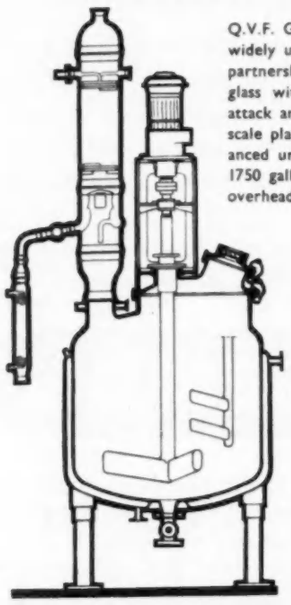

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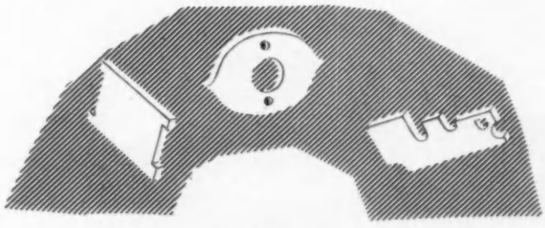

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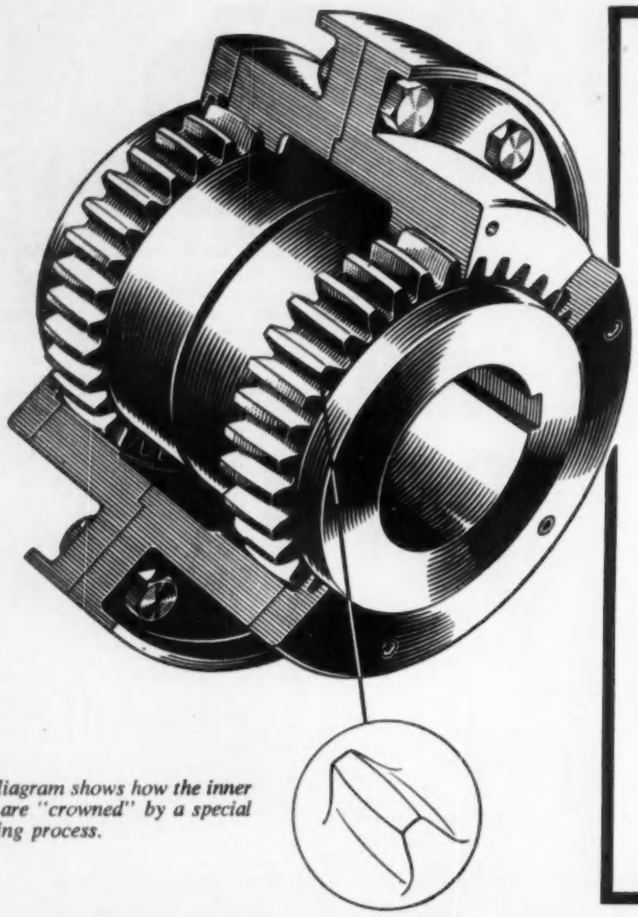

The diagram shows how the inner teeth are "crowned" by a special grinding process.

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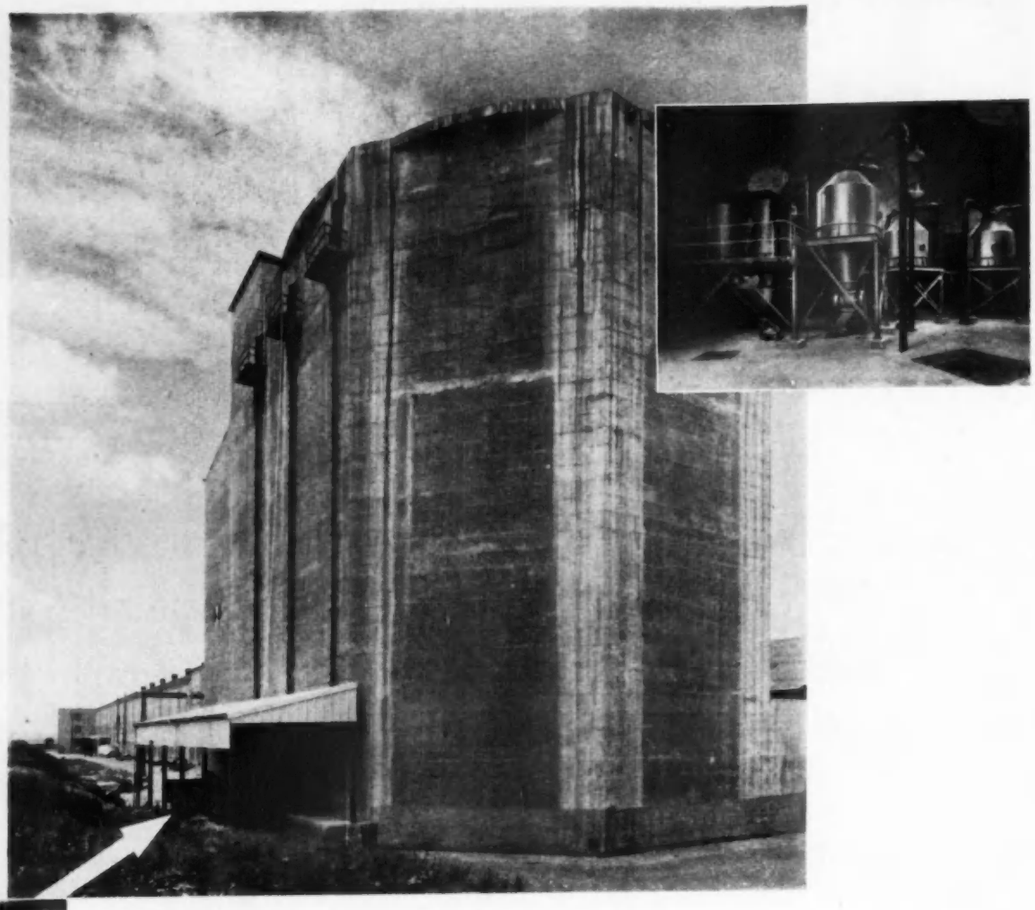
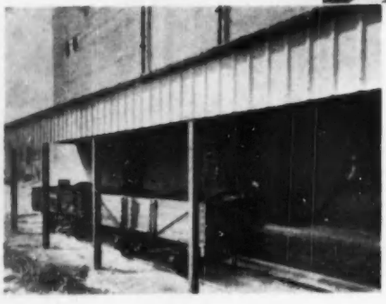


Three Sturtevant conveying pipe lines and inset (right) part of the receiving and separating sections. The Sturtevant plants unload bulk material from railway wagons and convey to the top of the building.



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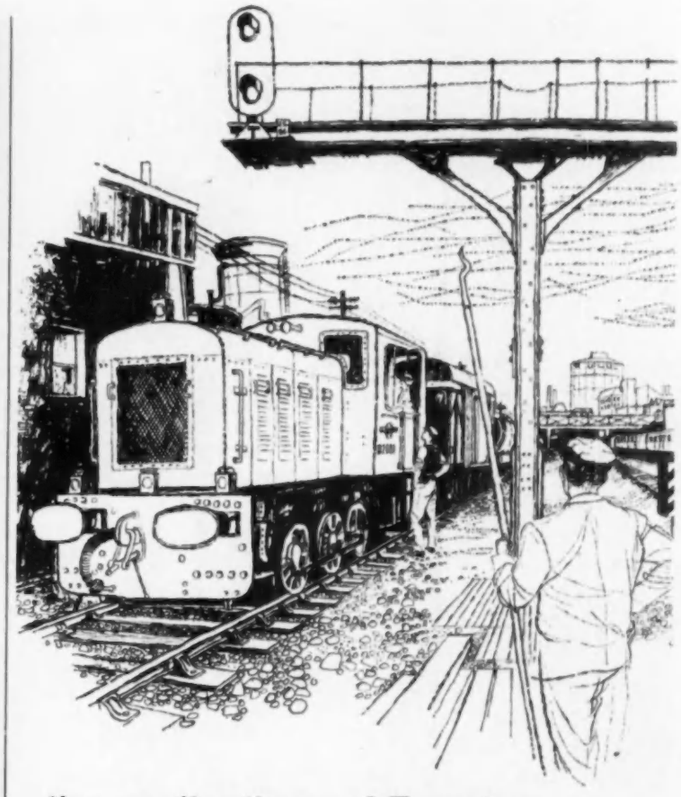

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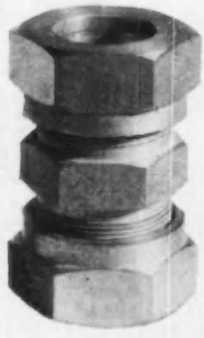

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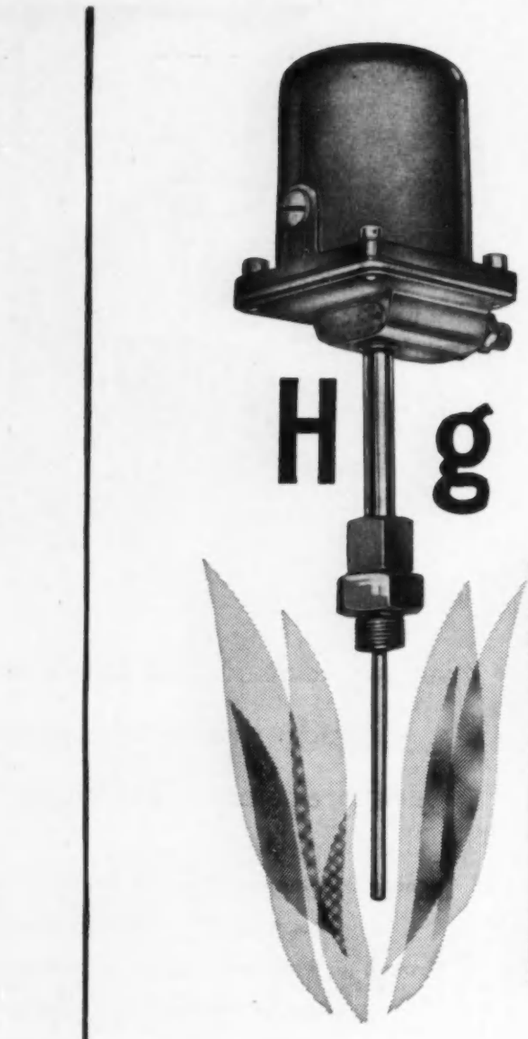

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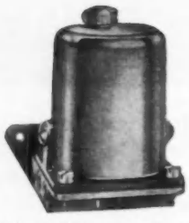

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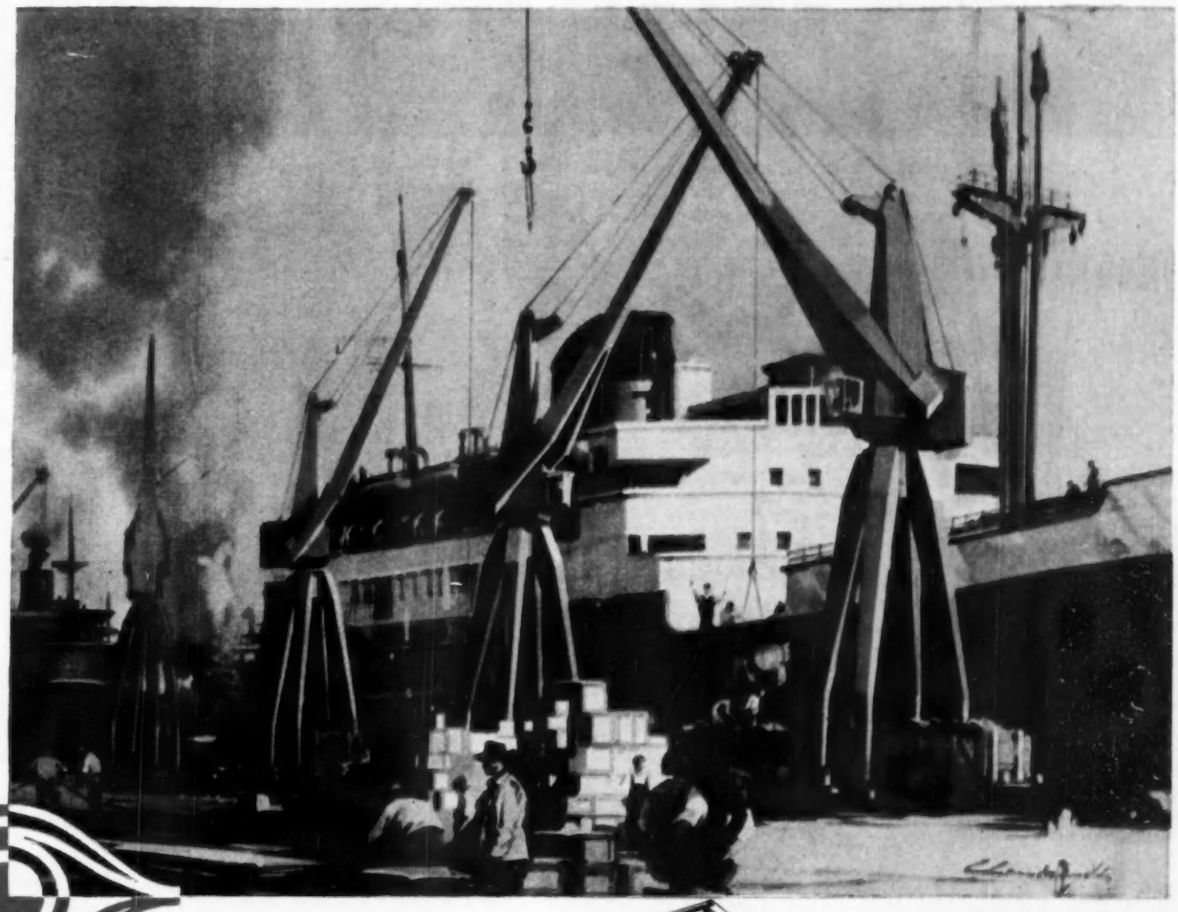

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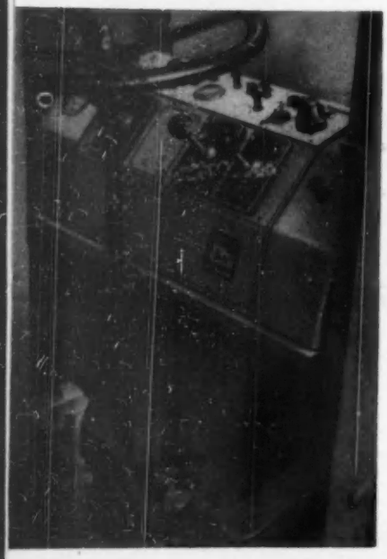

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Coles finger-tip control, supplied by simple electric pilot switches, ensures a fatigue-free, alert operator who will be as efficient at the end of the day as at the beginning—an important factor, embracing economy and safety.

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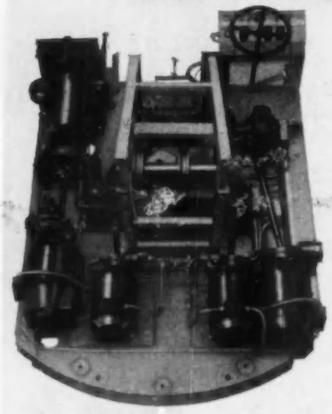
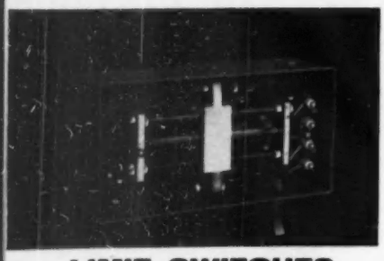


Coles have cleared the deck with their diesel-electric system. This clean, simple layout—the delight of discerning engineers— comprises separate, self-contained and easily removable units with maximum possible accessibility. Maintenance and servicing is faster —and down-time is reduced to a minimum.



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Self-resetting limit switches automatically operate should attempts be made to hoist or derrick beyond permitted limits.

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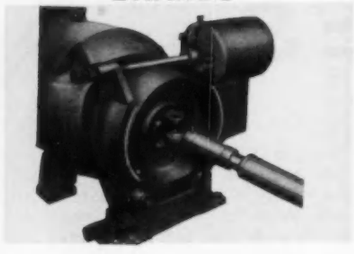
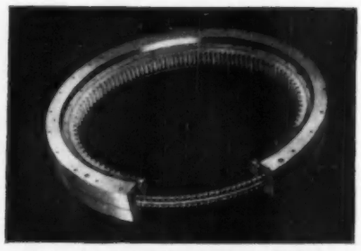


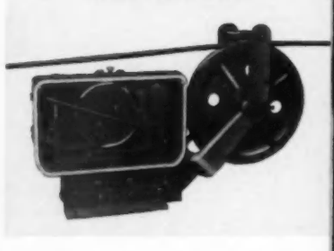
Operate instantly and automatically if the power supply is interrupted.



SLEW BEARING RING

This large diameter double ball-race bearing, linking chassis and superstructure, ensures smooth and accurate slewing.

SAFE LOAD INDICATOR



Coles safe load indicator automatically prevents lifting of an unsafe load throughout the 360 degrees of slew.

COLES

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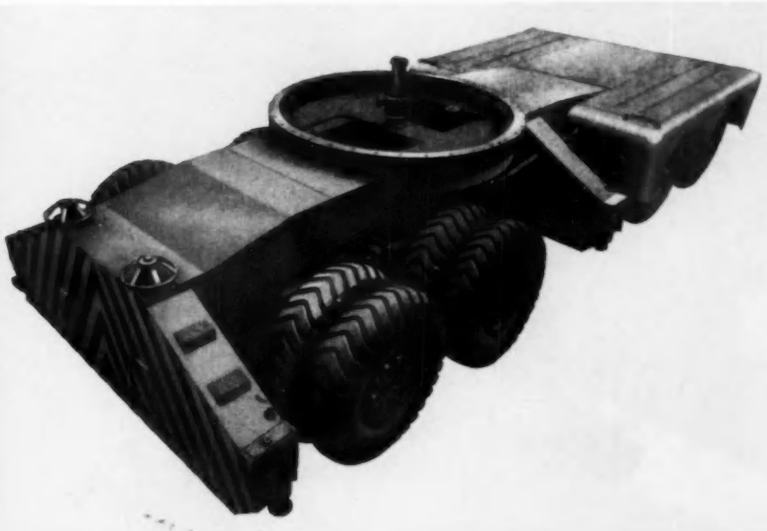

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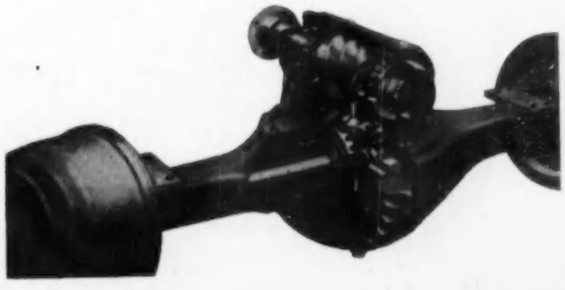

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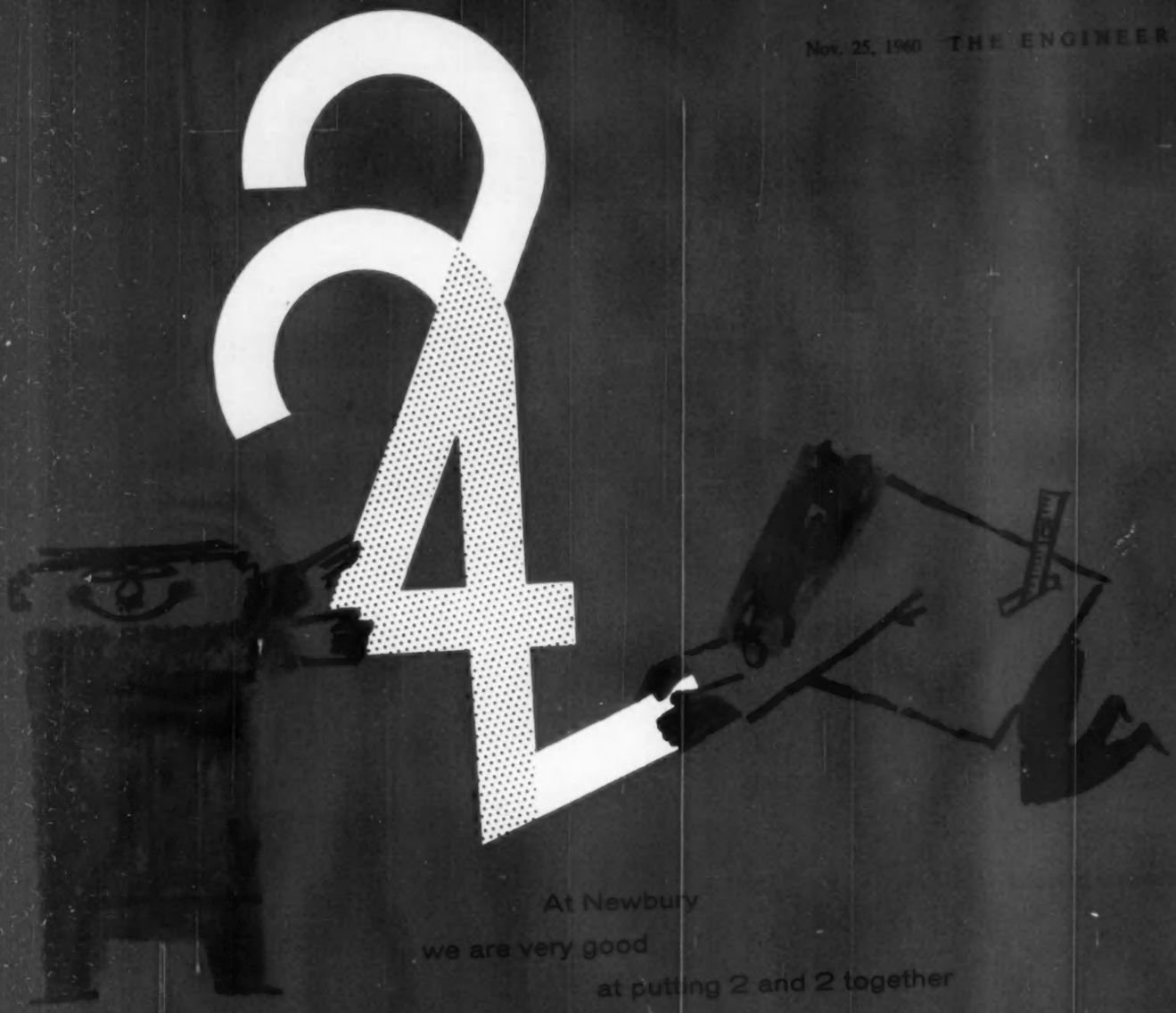

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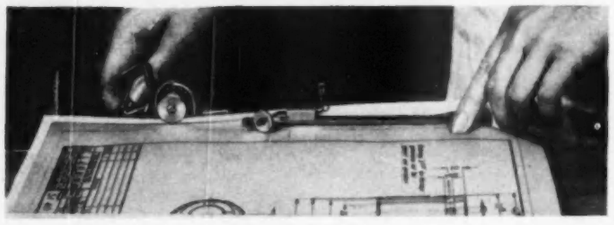

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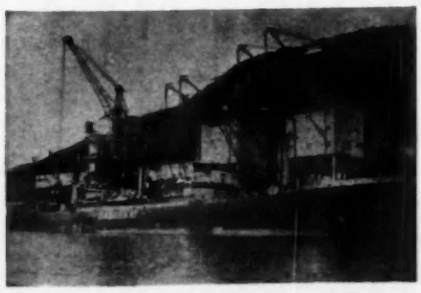

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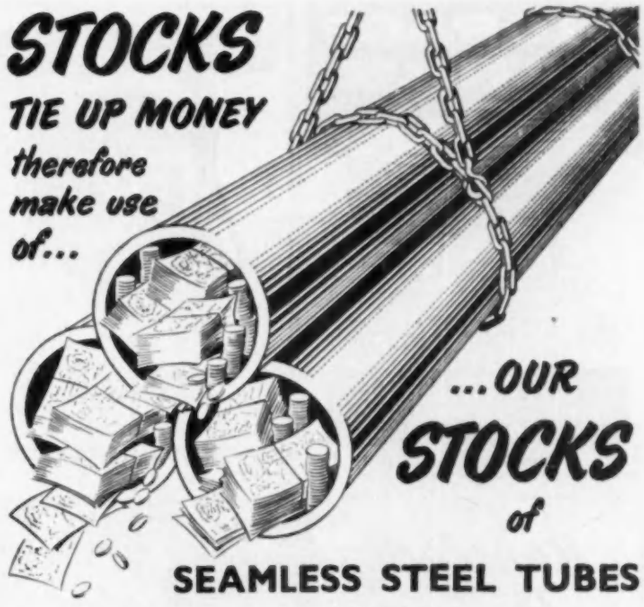

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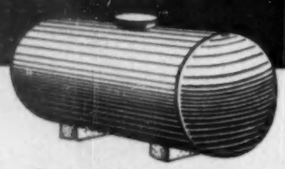

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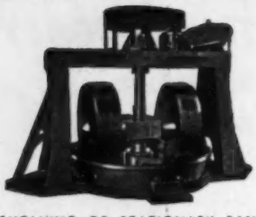

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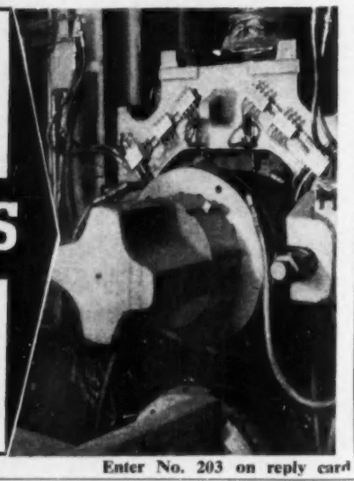

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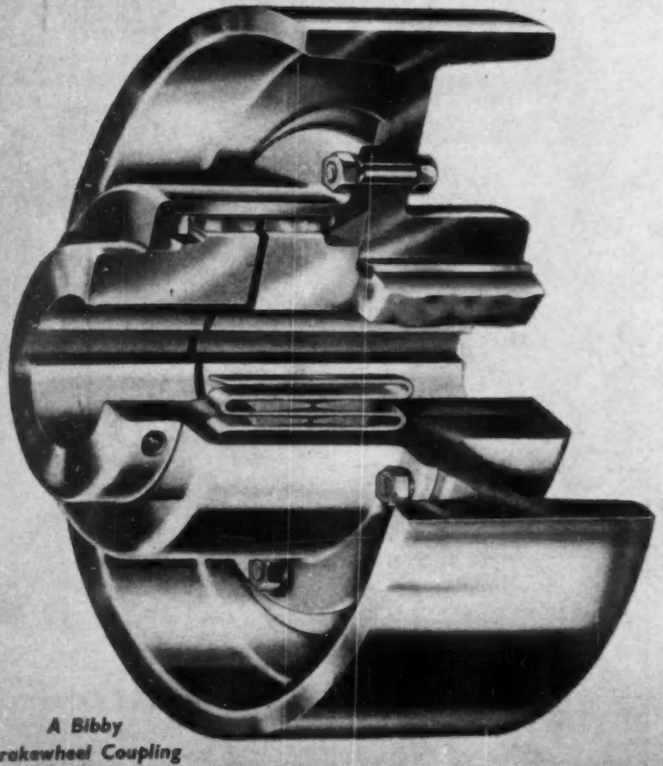

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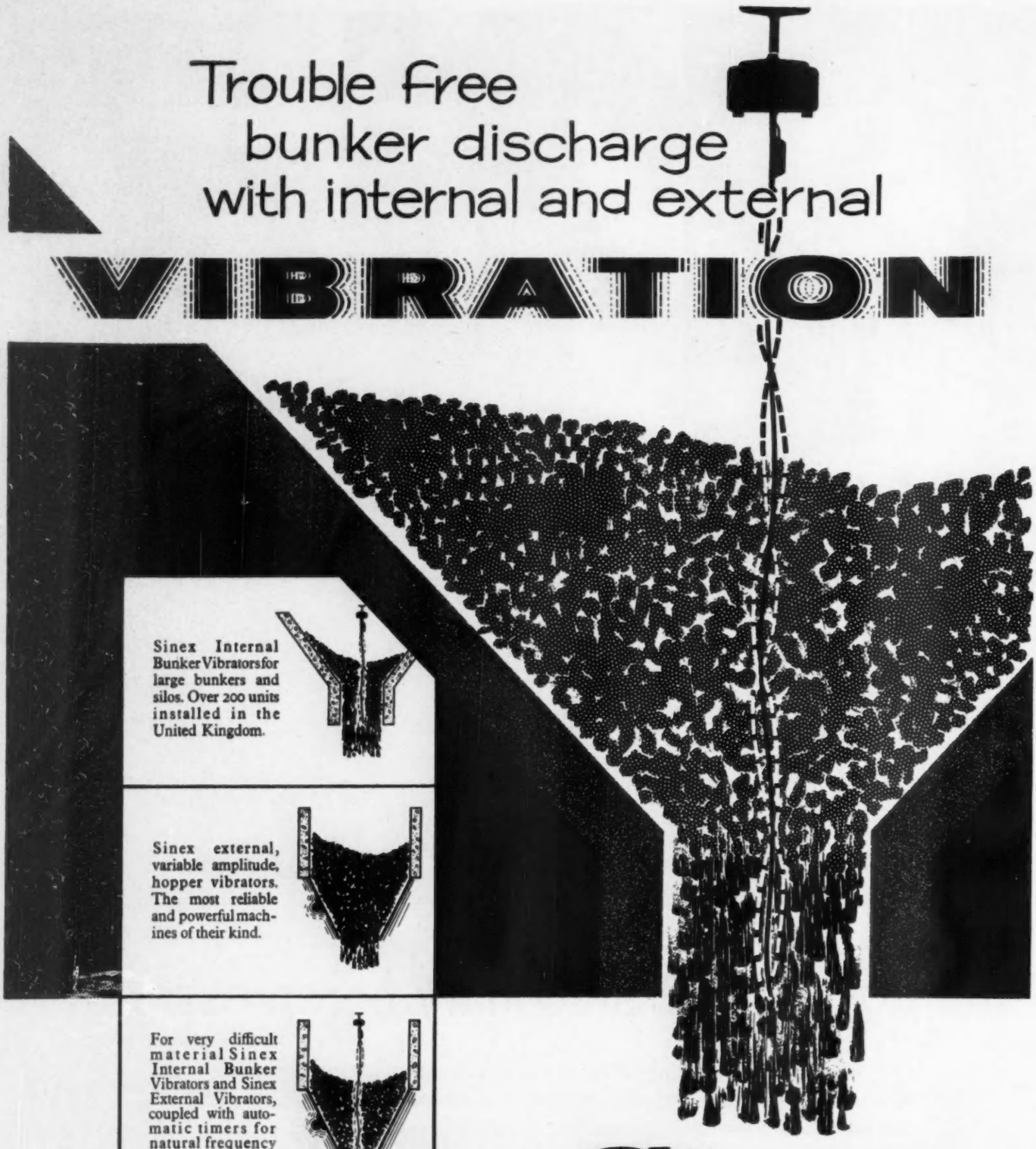

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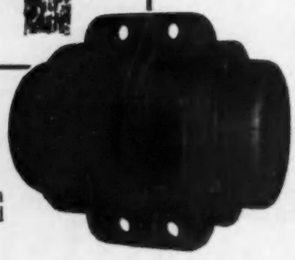

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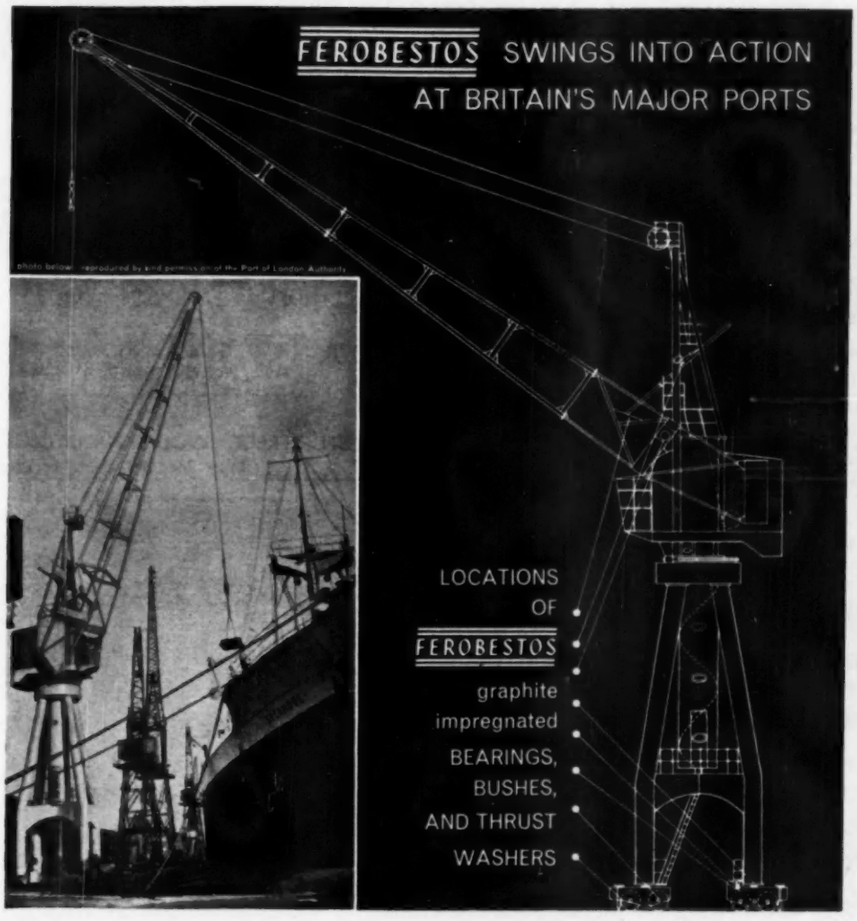

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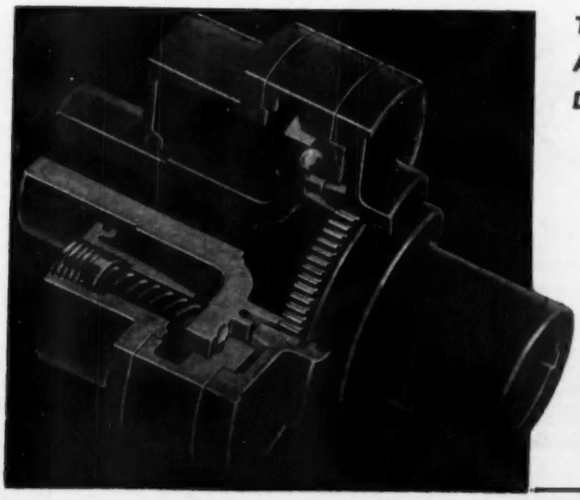

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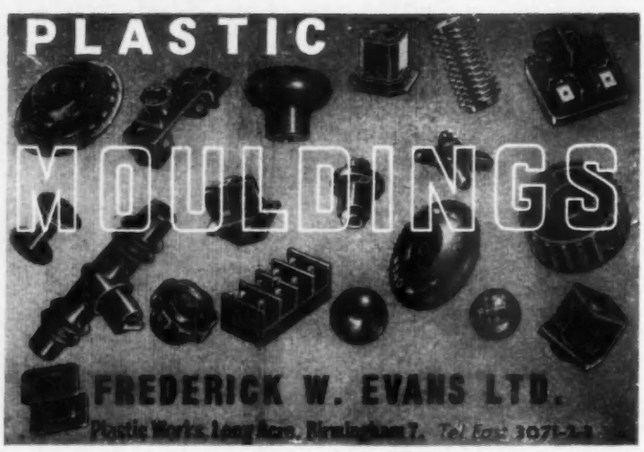

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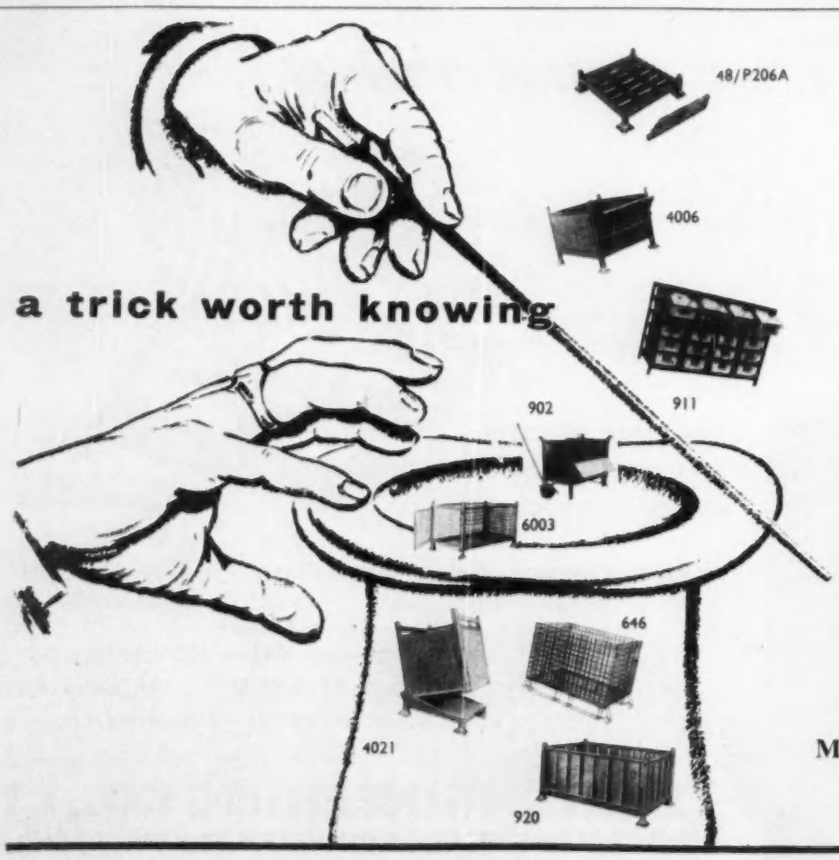

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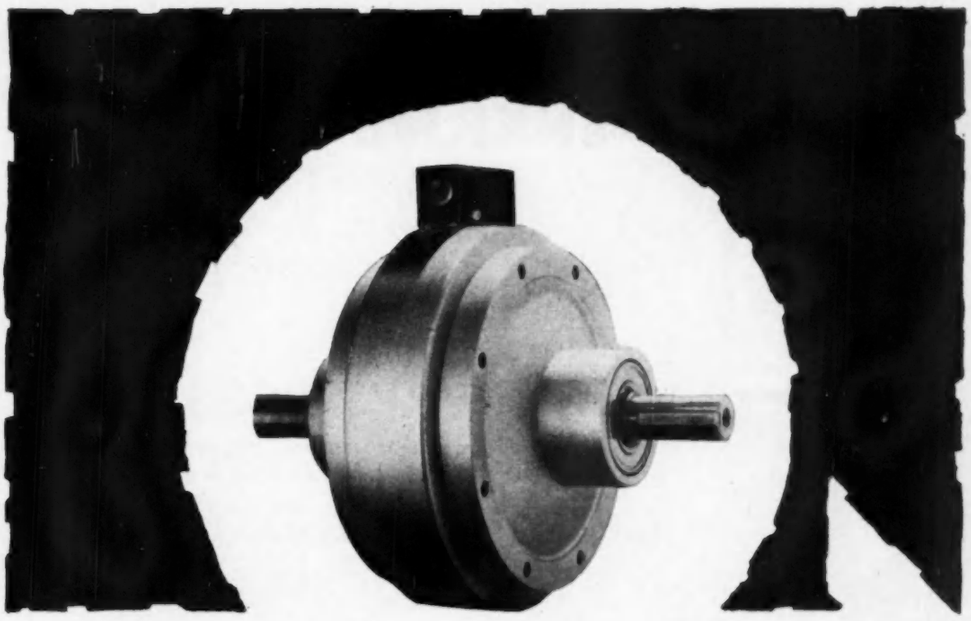

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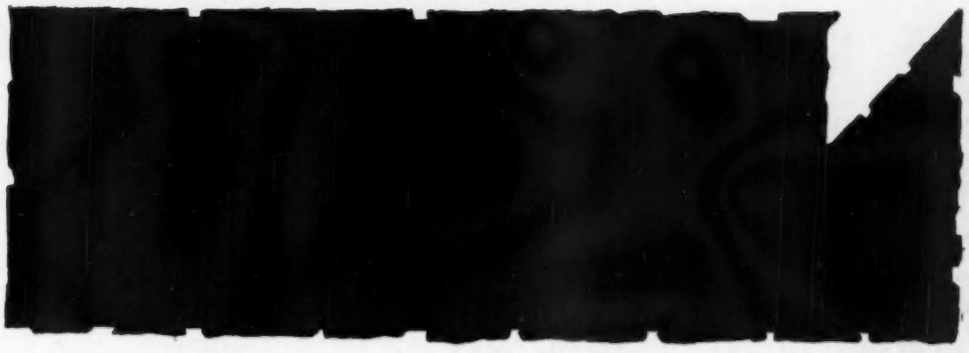

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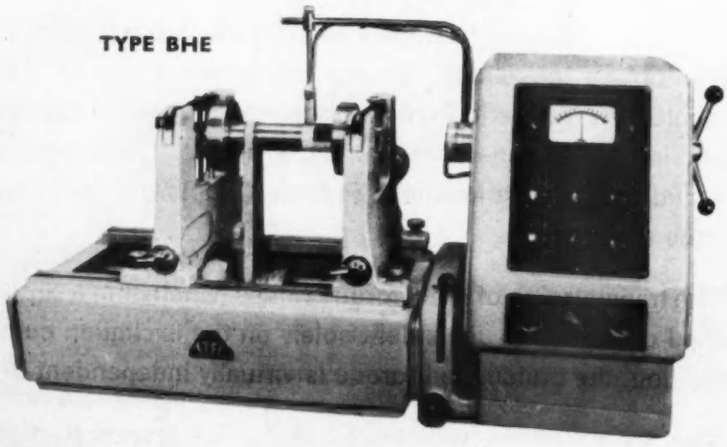

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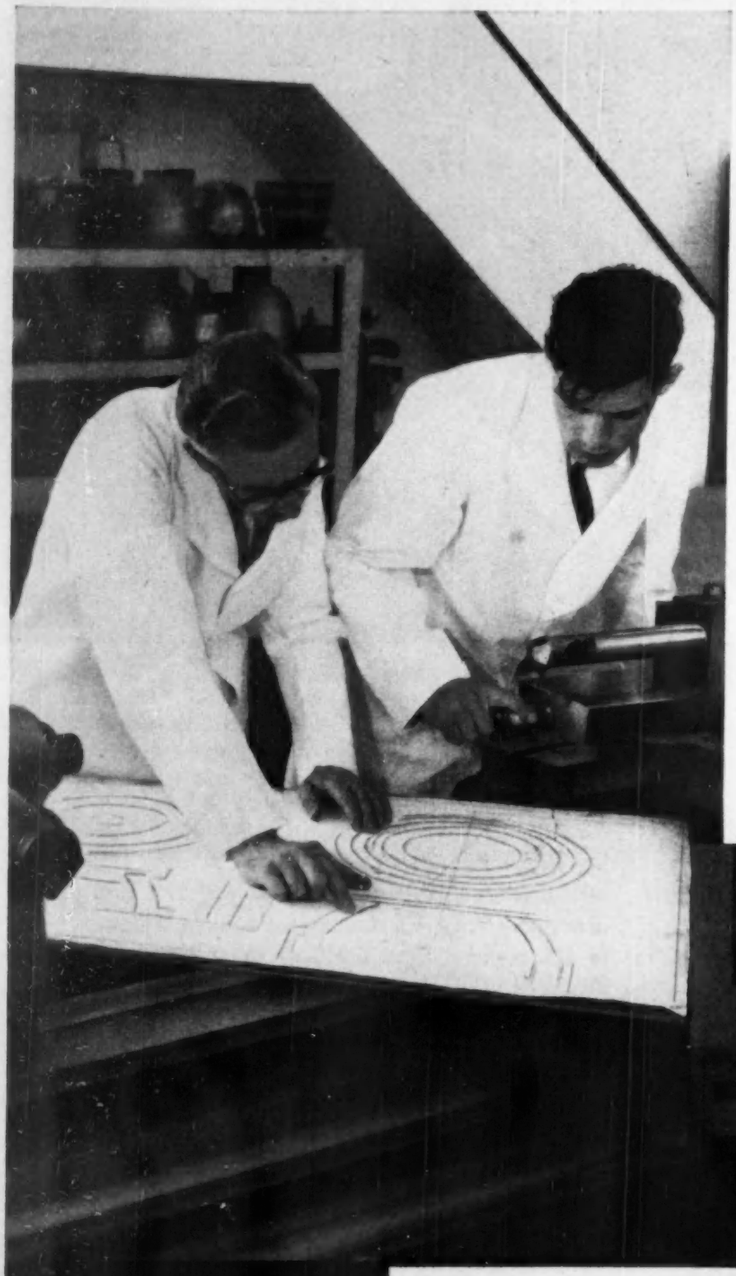

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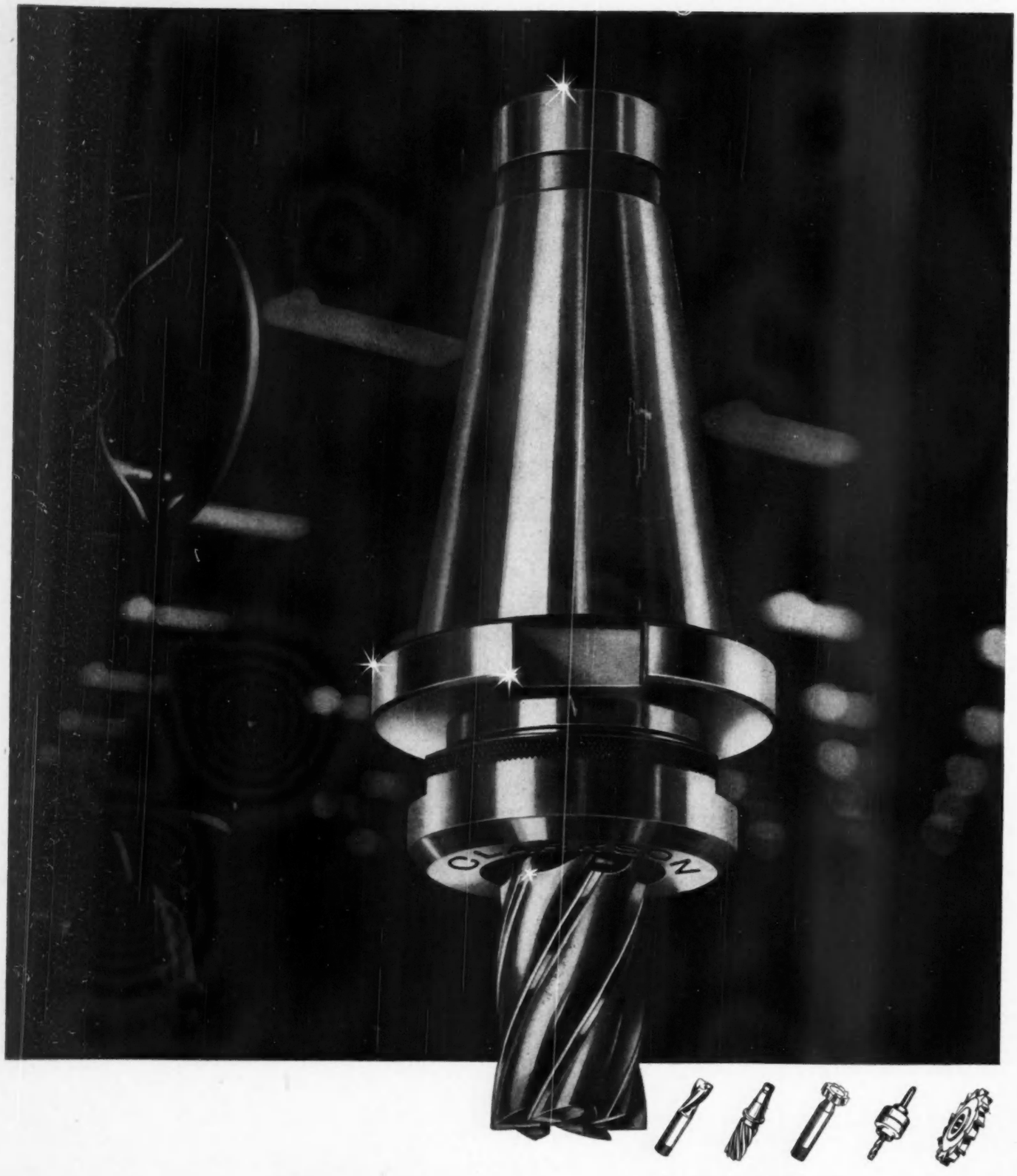

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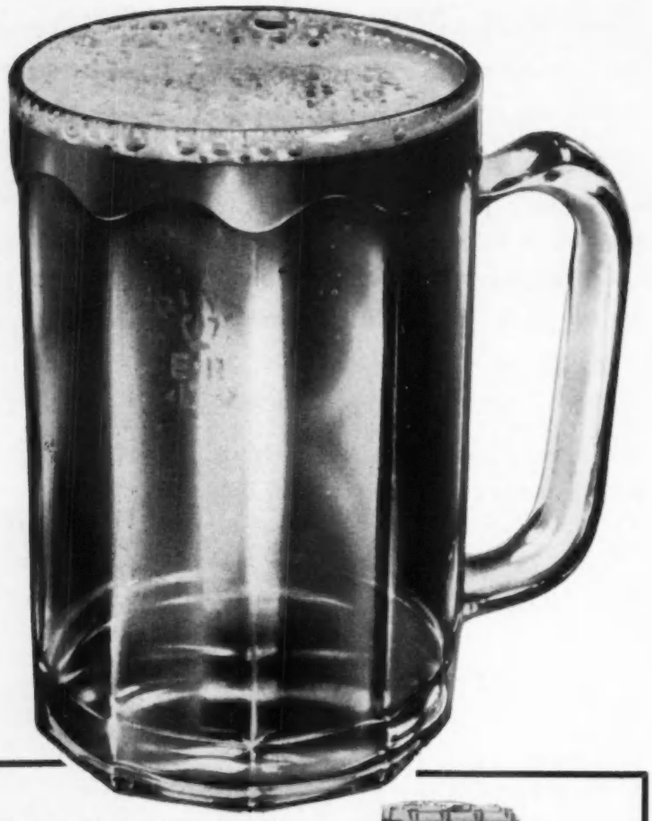

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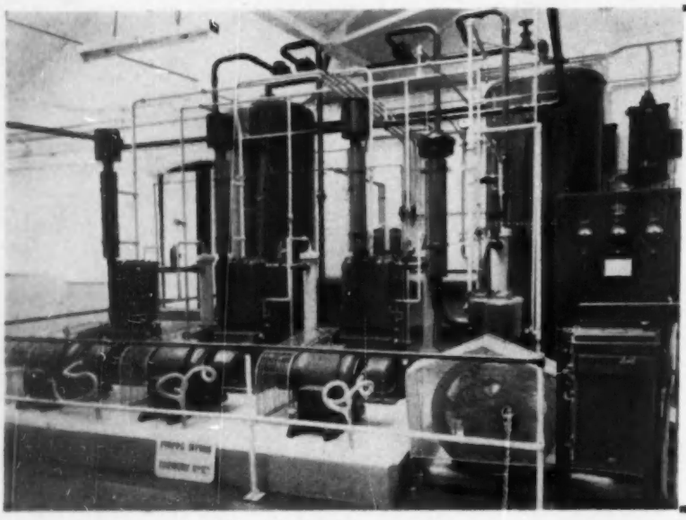

Three of the latest type "BROOMWADE" Type C660 Carbon Ring Oil-Free Air Compressors installed by Messrs. Phipps Northampton Brewery Company Limited, by whose courtesy this photograph is reproduced.

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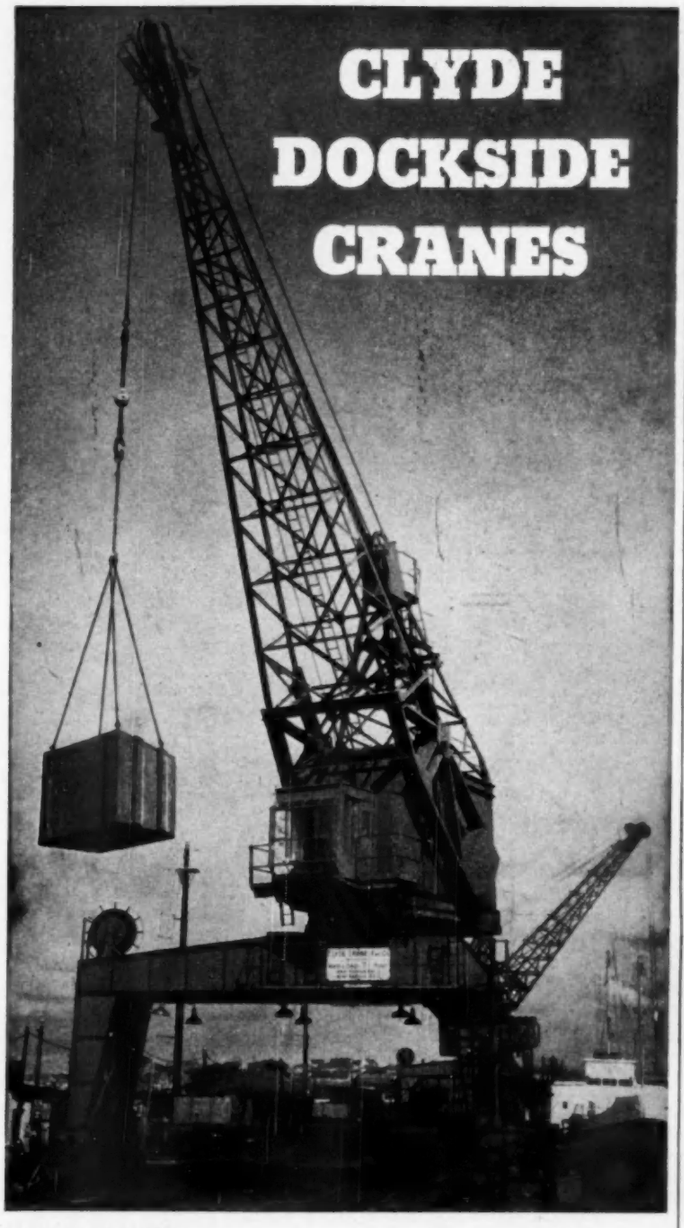

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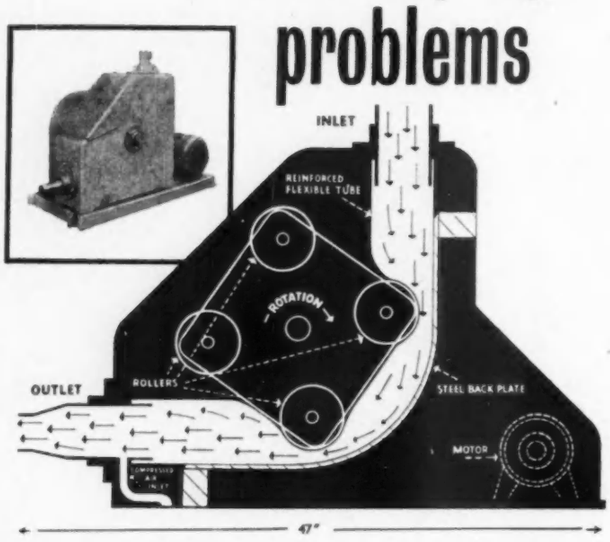

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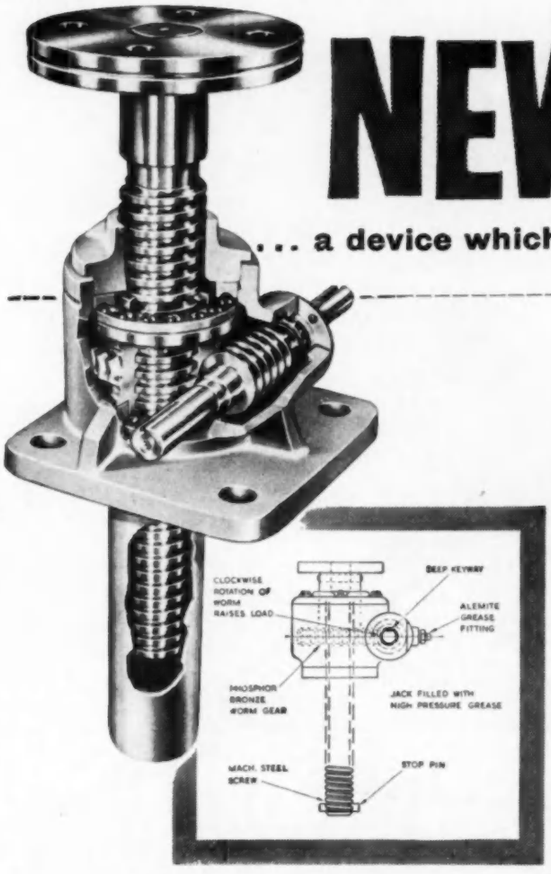

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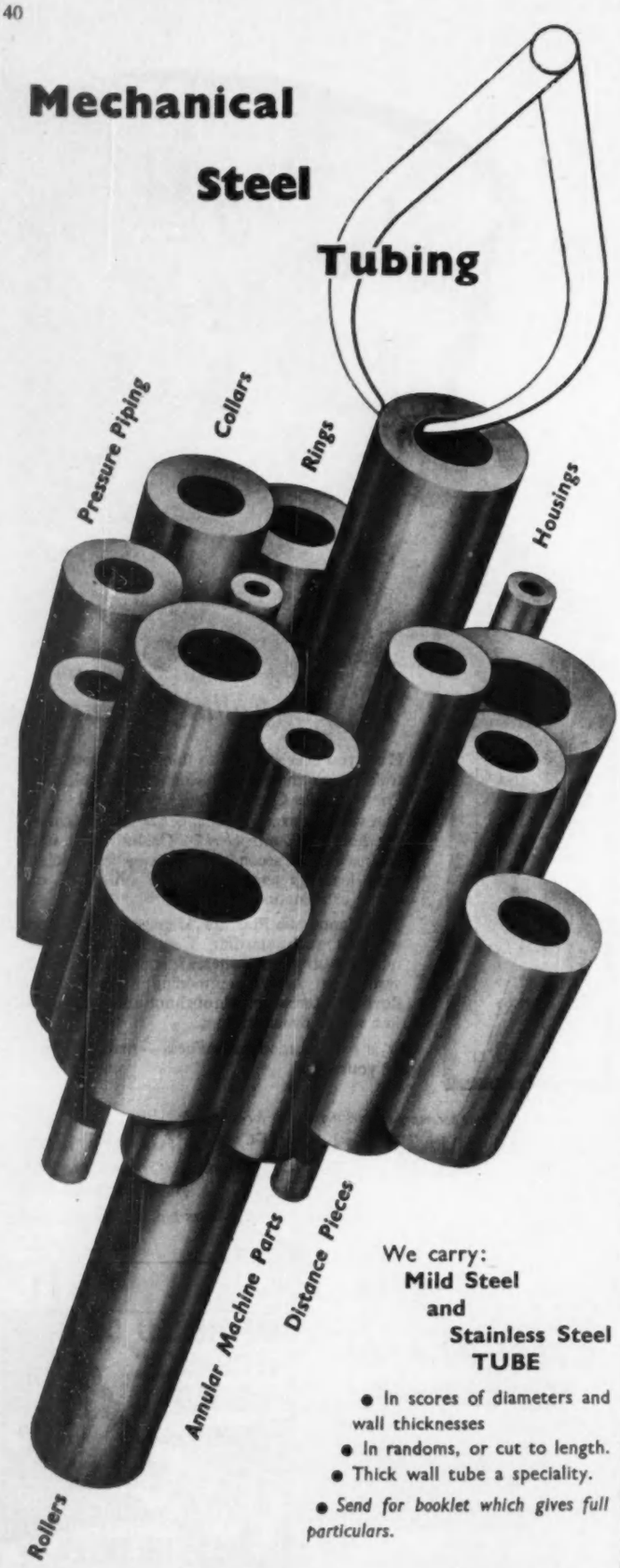

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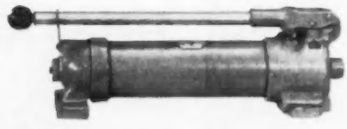

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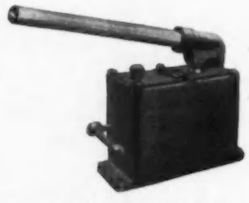

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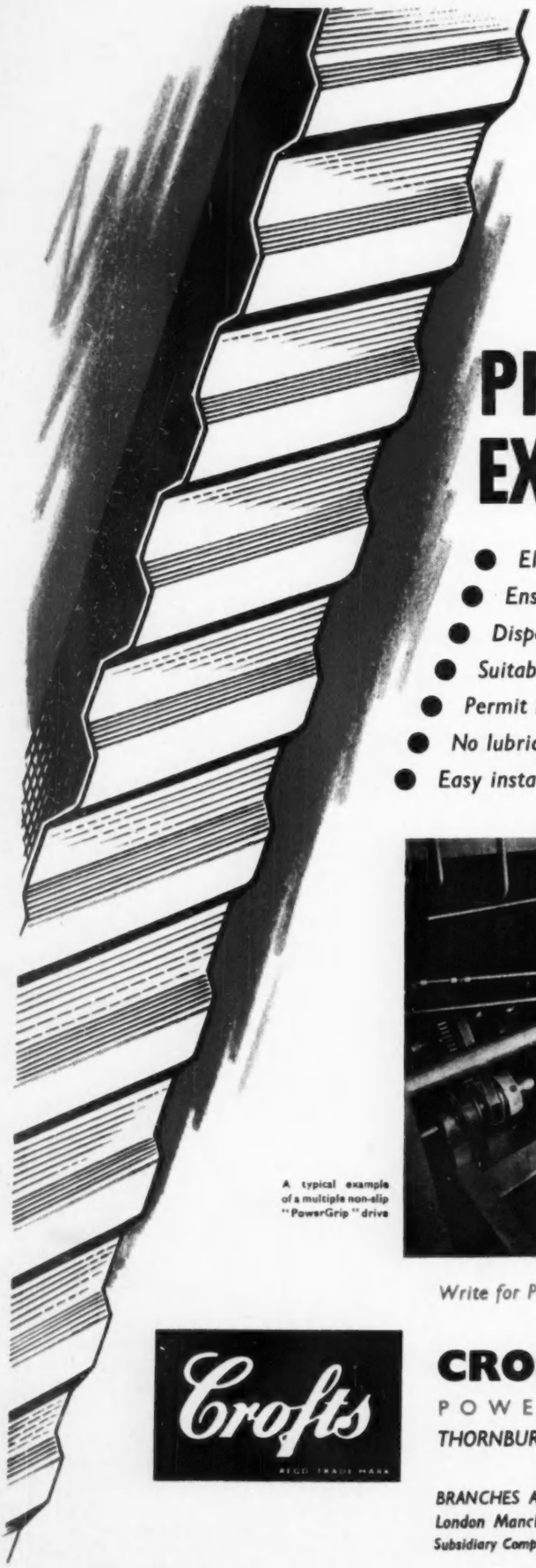

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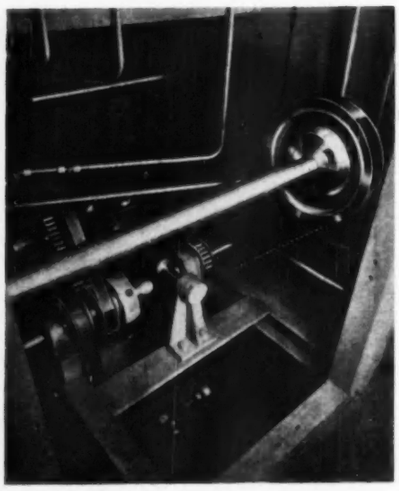

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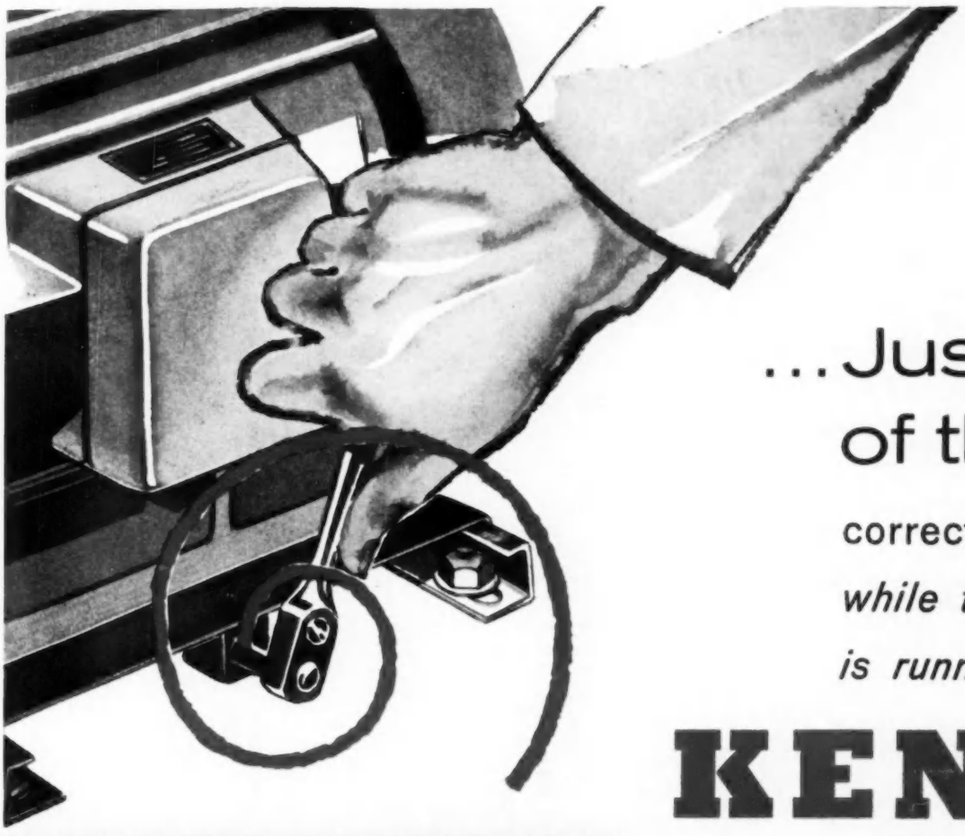

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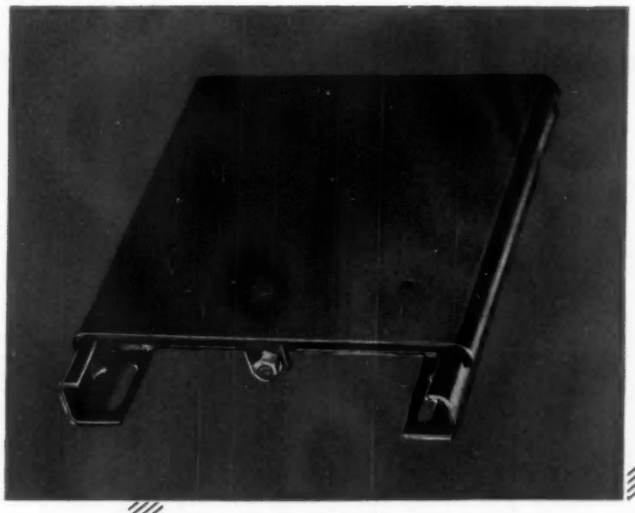

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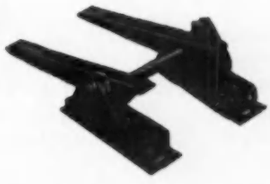

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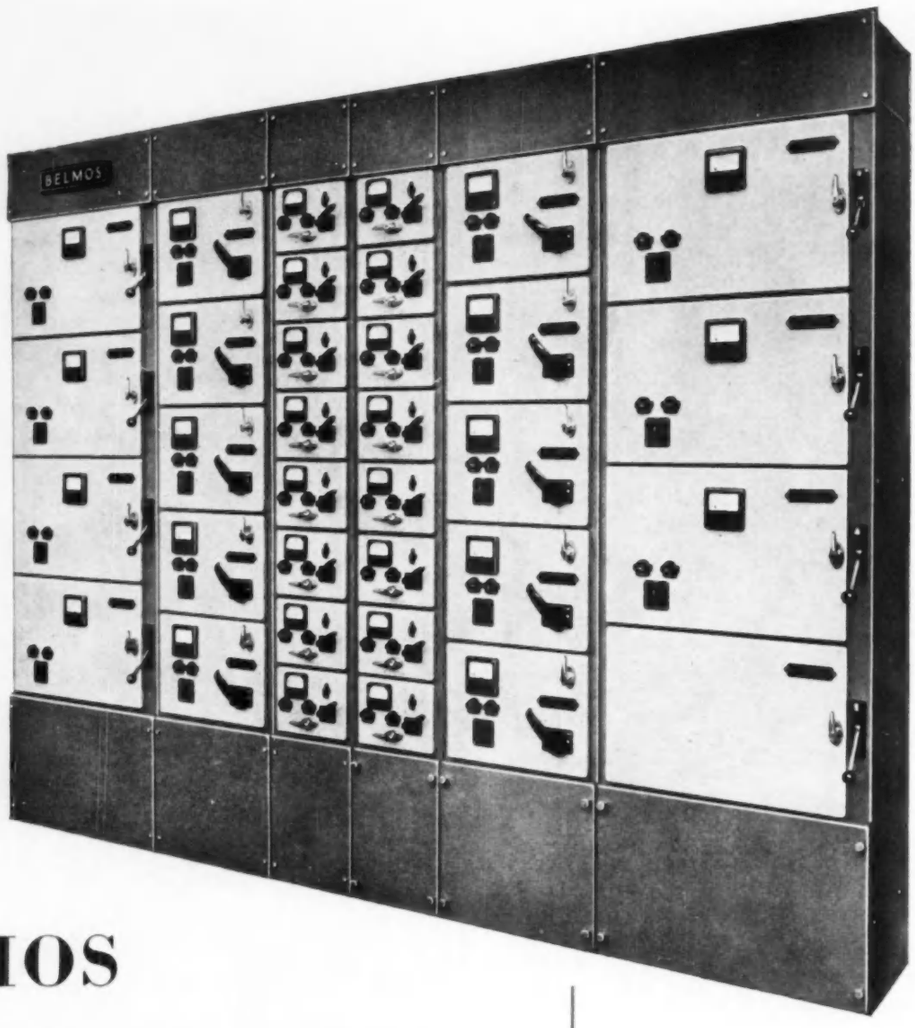

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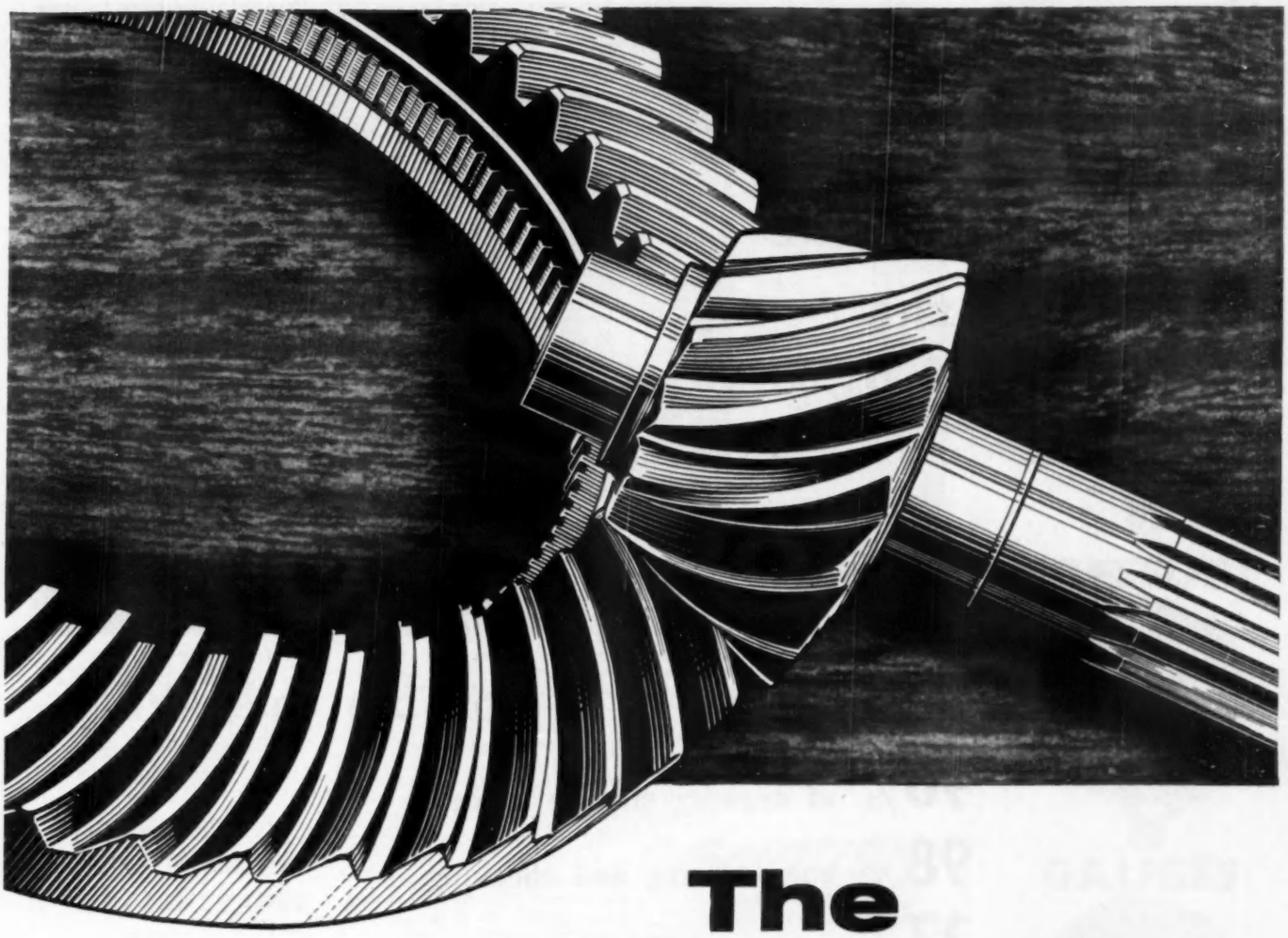

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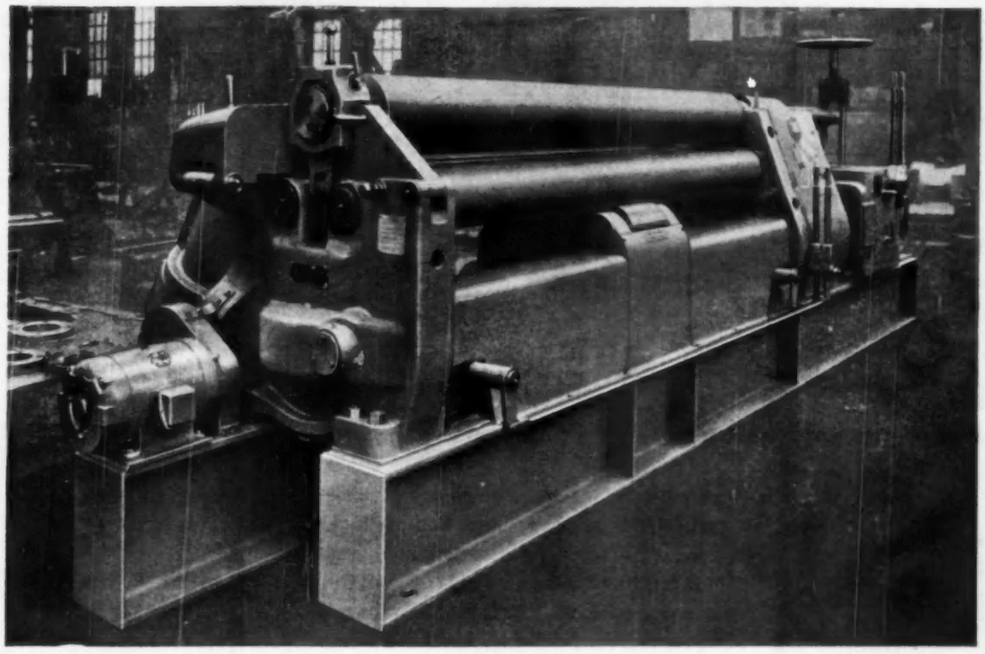

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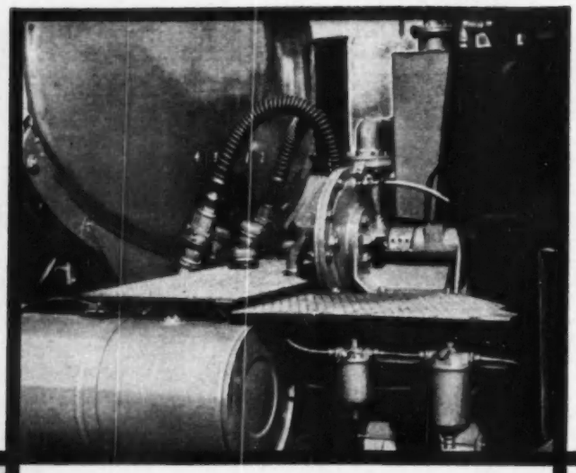

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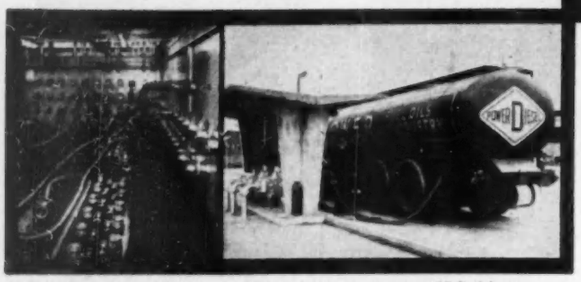

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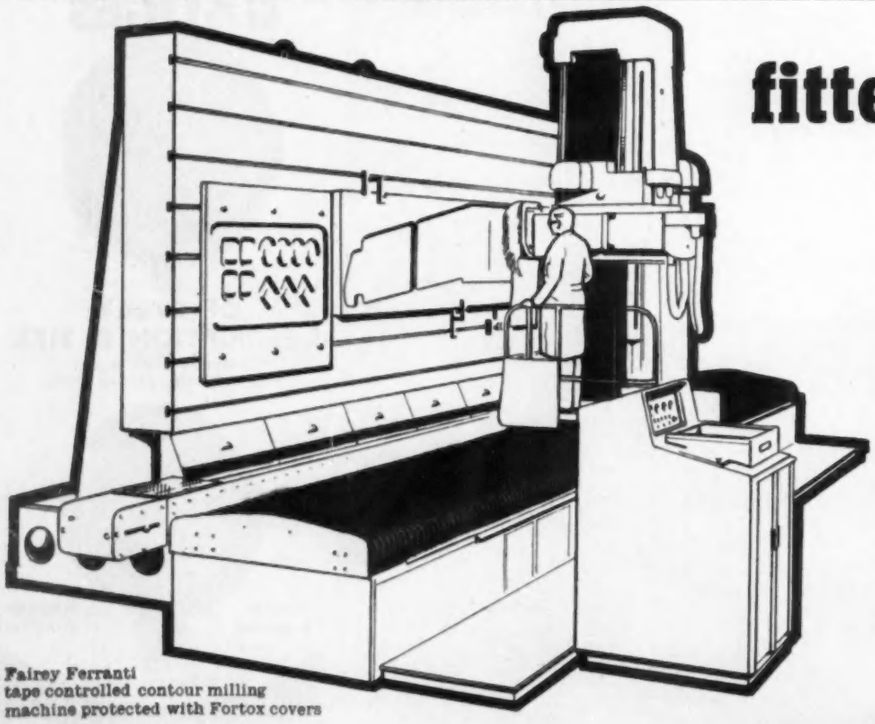

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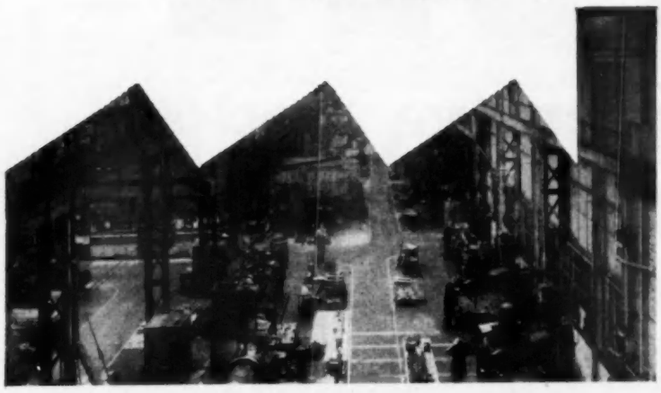

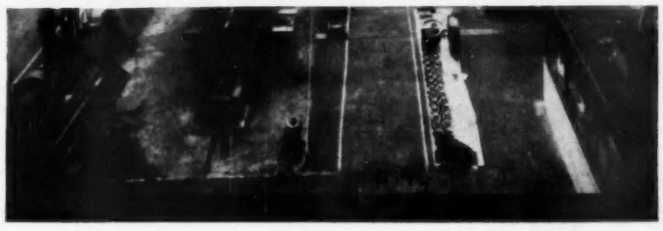

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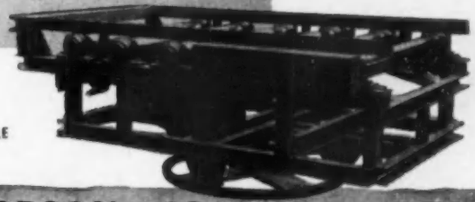

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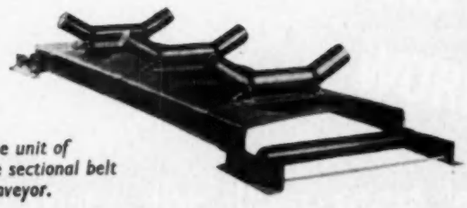

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(Left) *To* B.S. 1952. *With flanged ends.*

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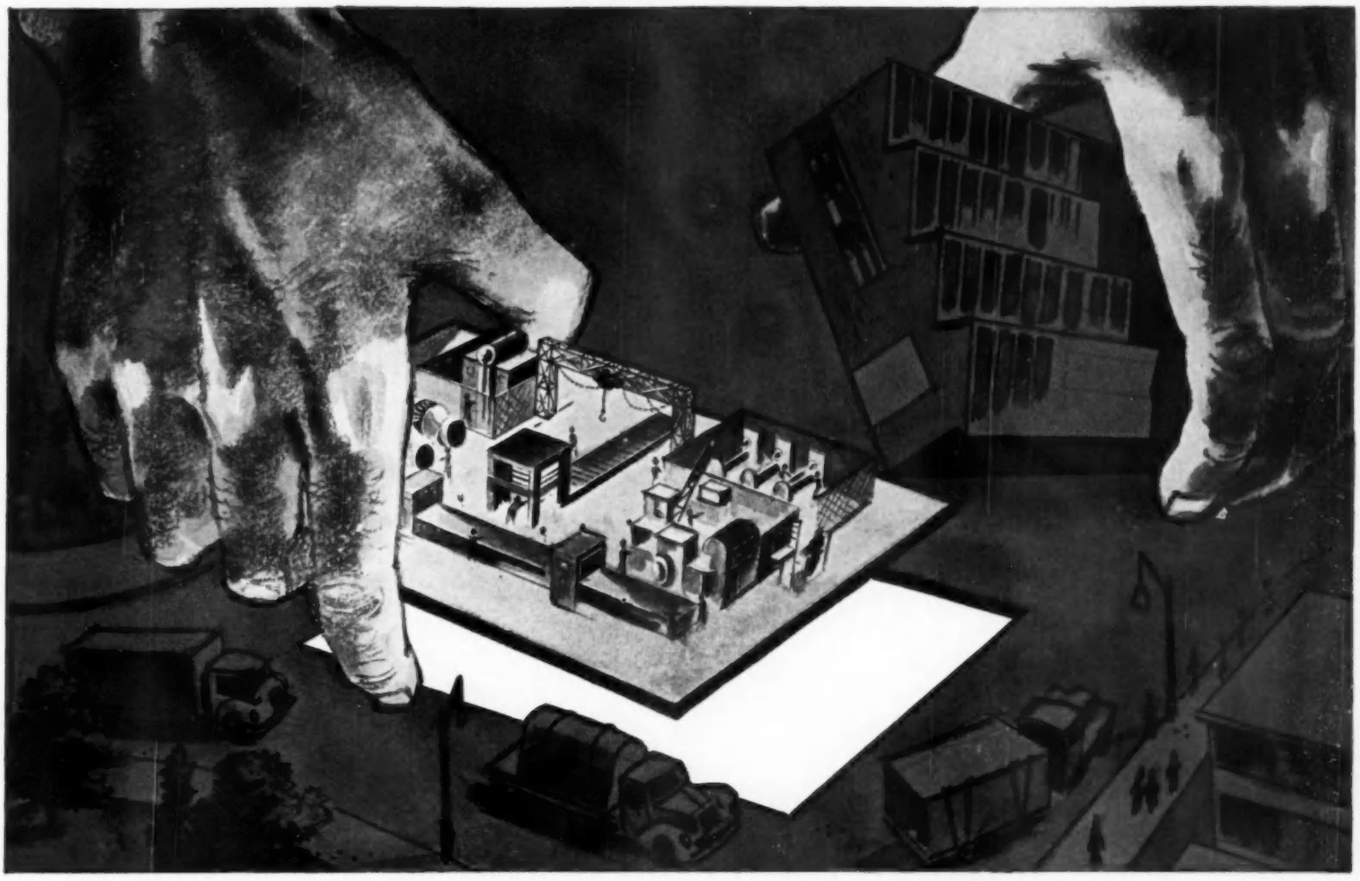

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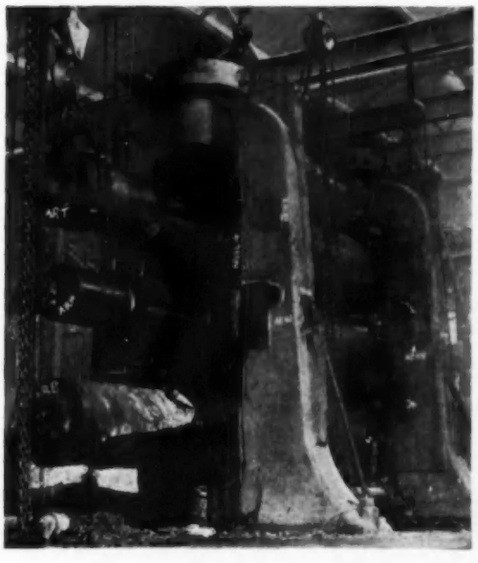

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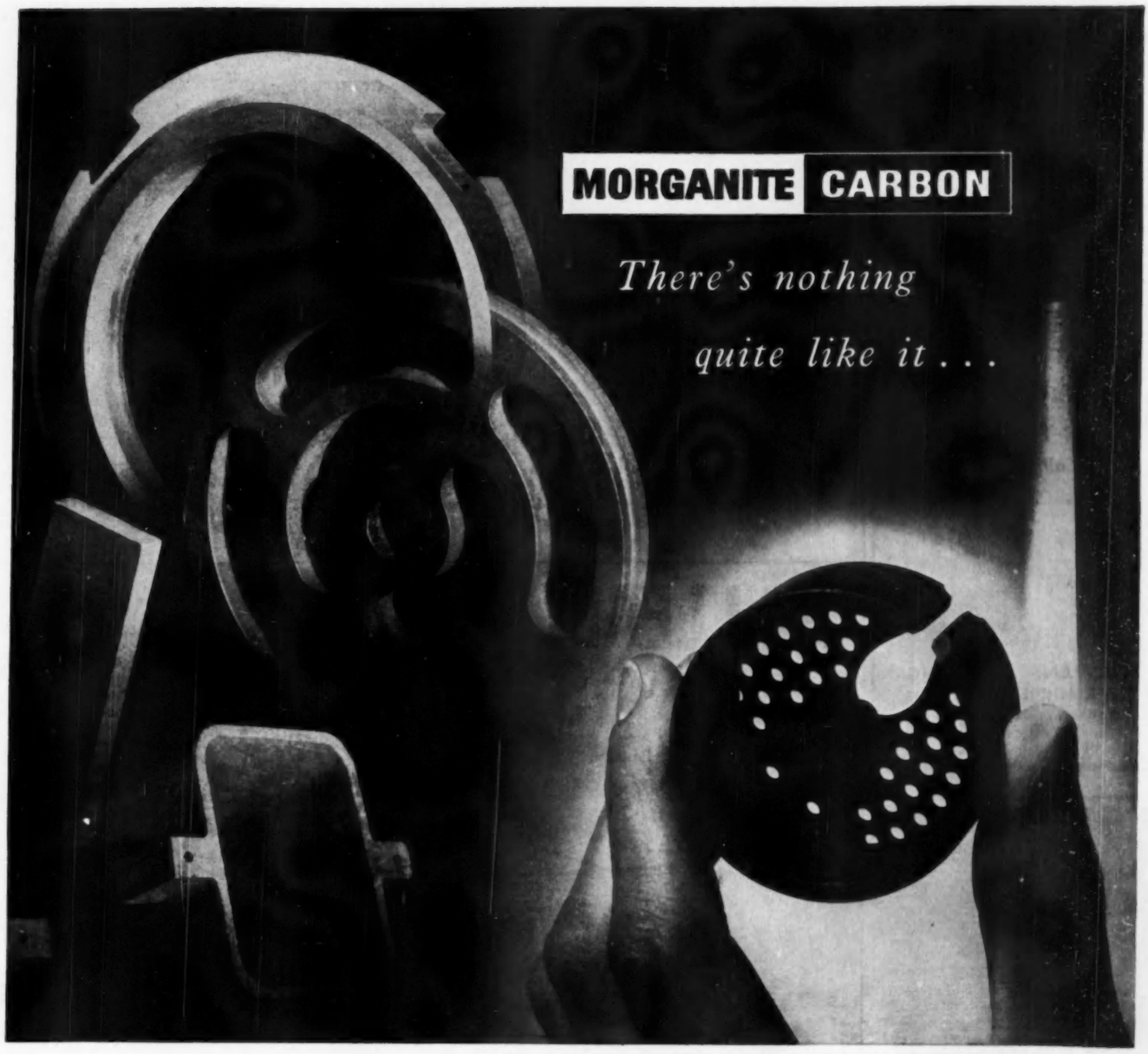

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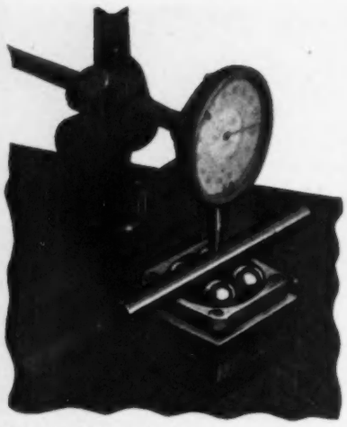

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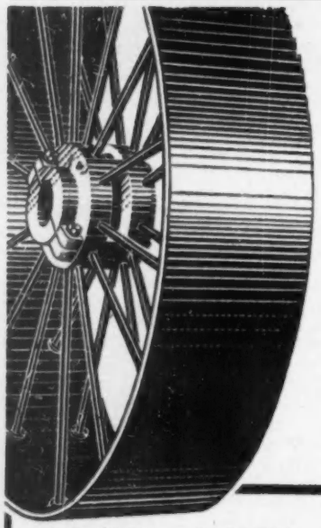

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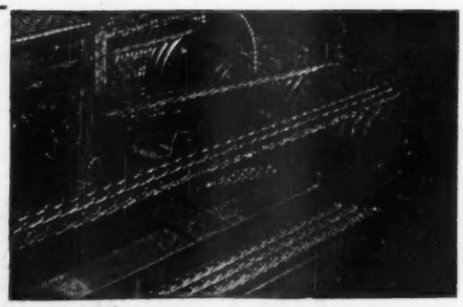

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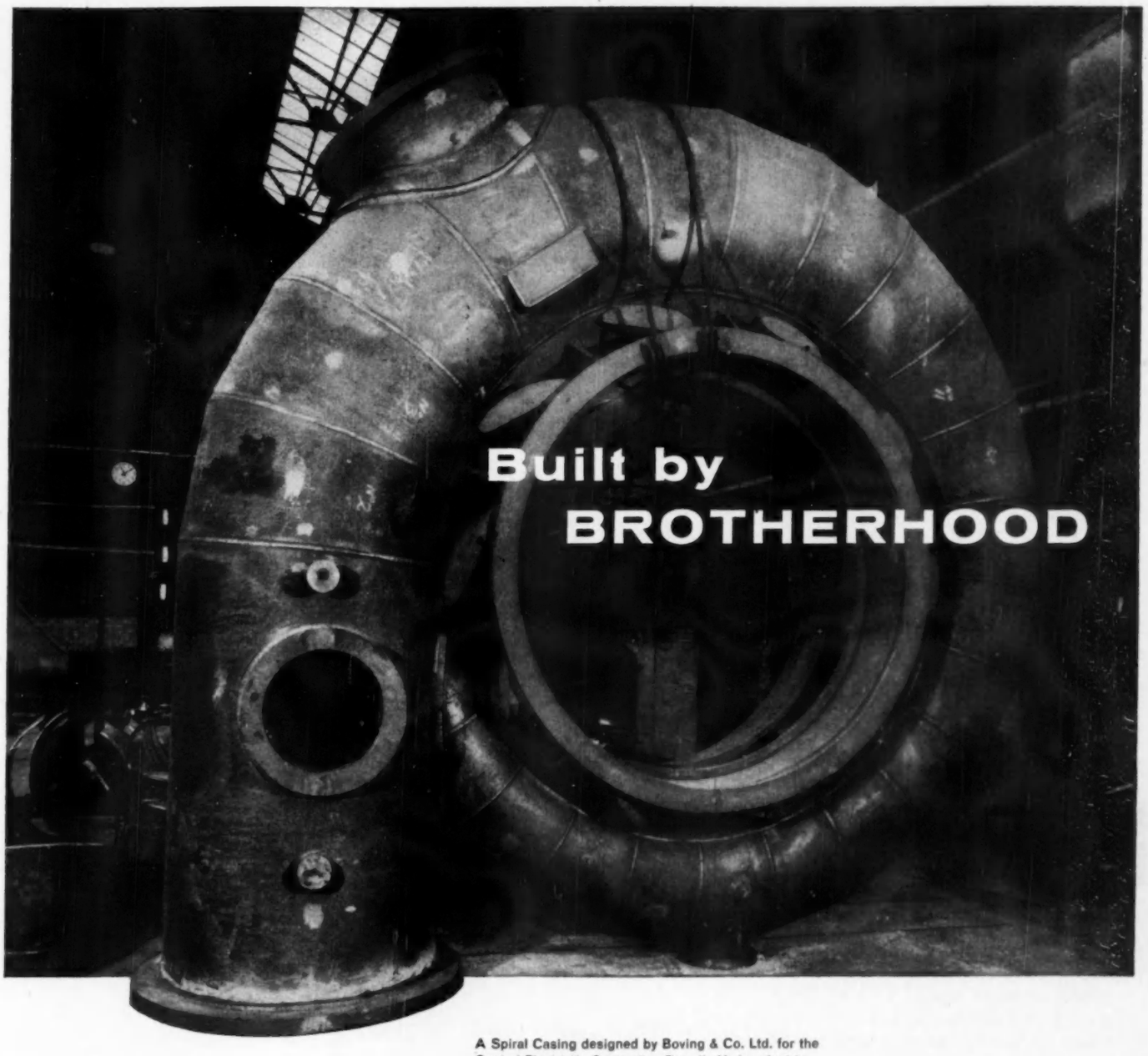

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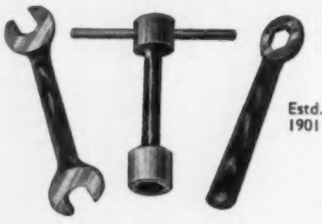

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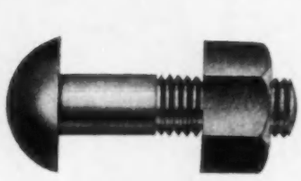
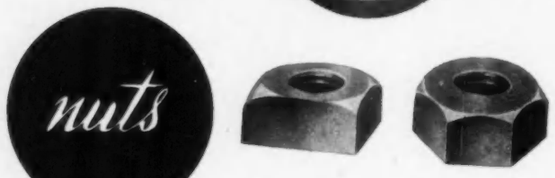


bolts



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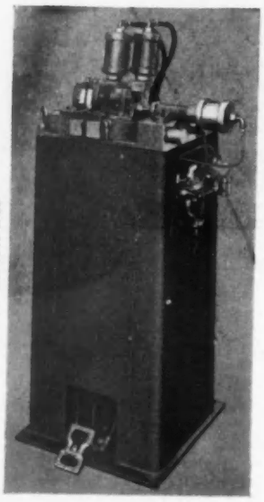

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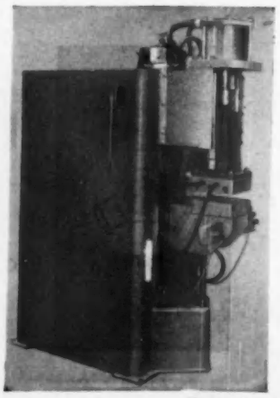

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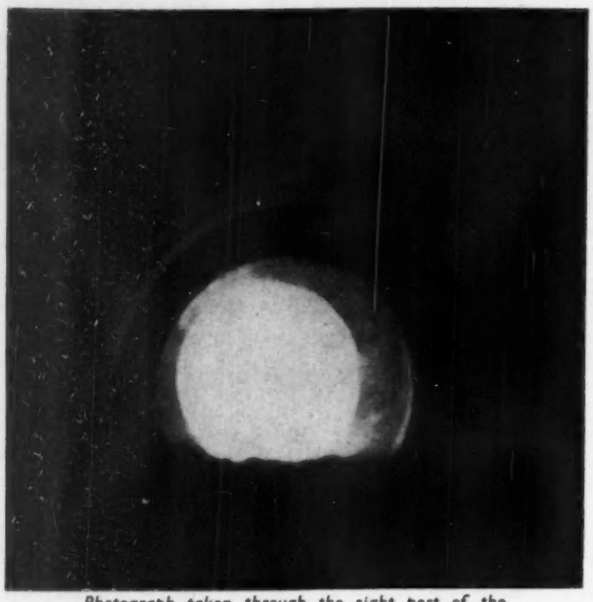

Photograph taken through the sight port of the combustion chamber of an Economic Boiler—approximate fuel ouput 350 lbs. per hour—CO_2 of over 13%—Smoke Number between 1 and 2

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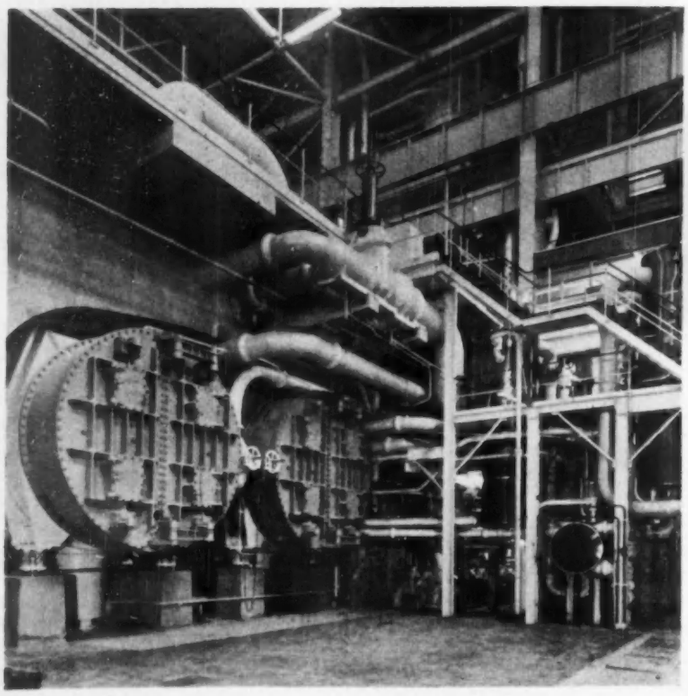

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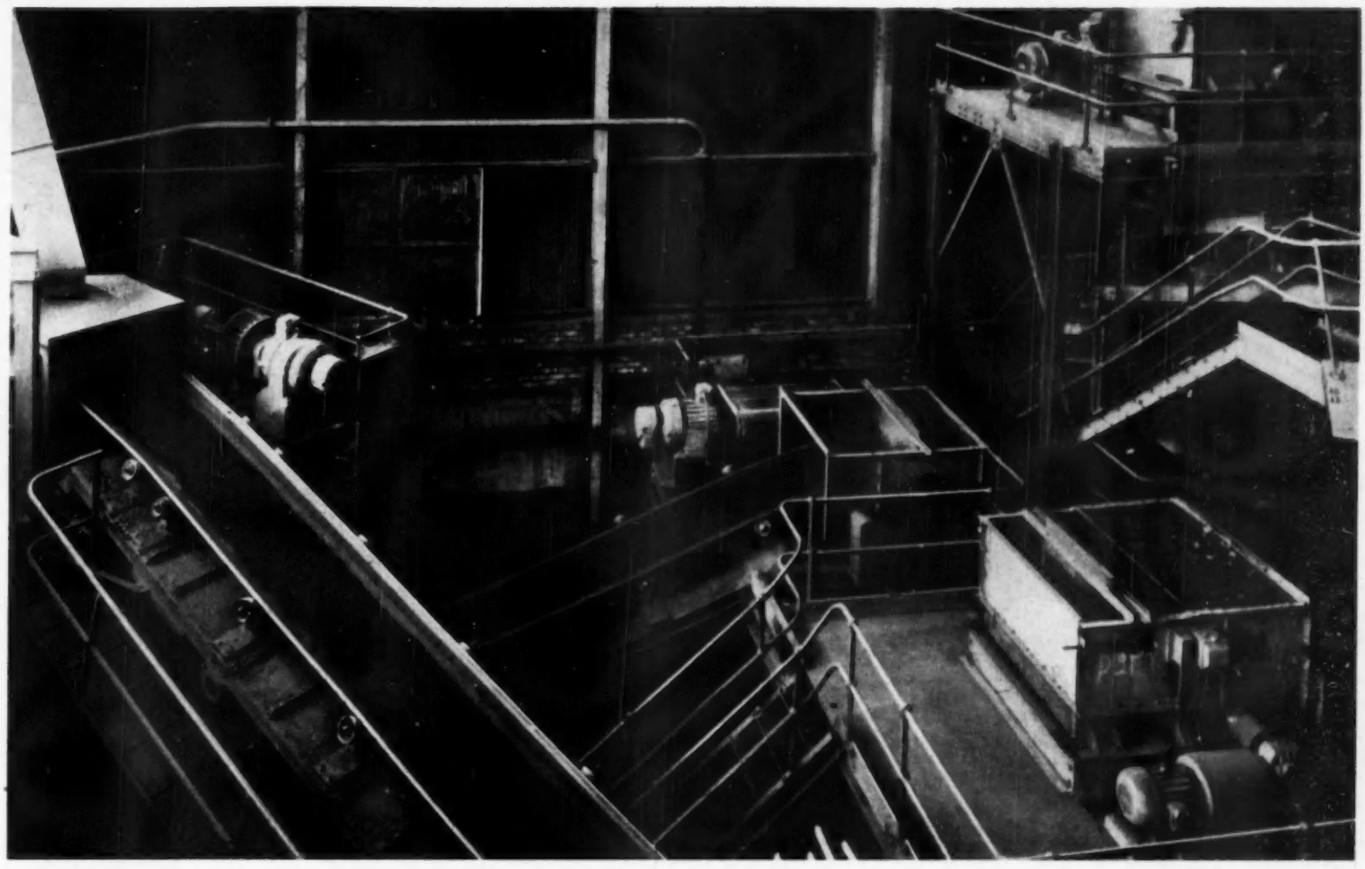

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is fitted to more than

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(78 have motors of less than 10 h.p.)

- **Light load start for motor**
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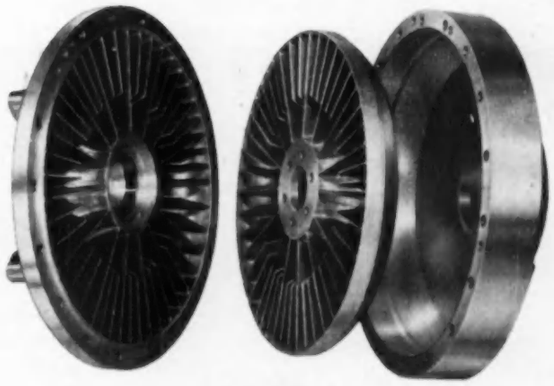

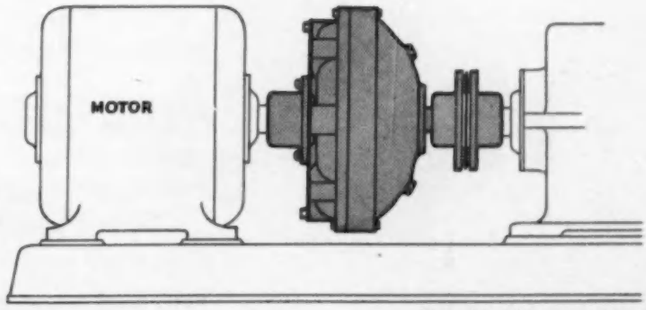

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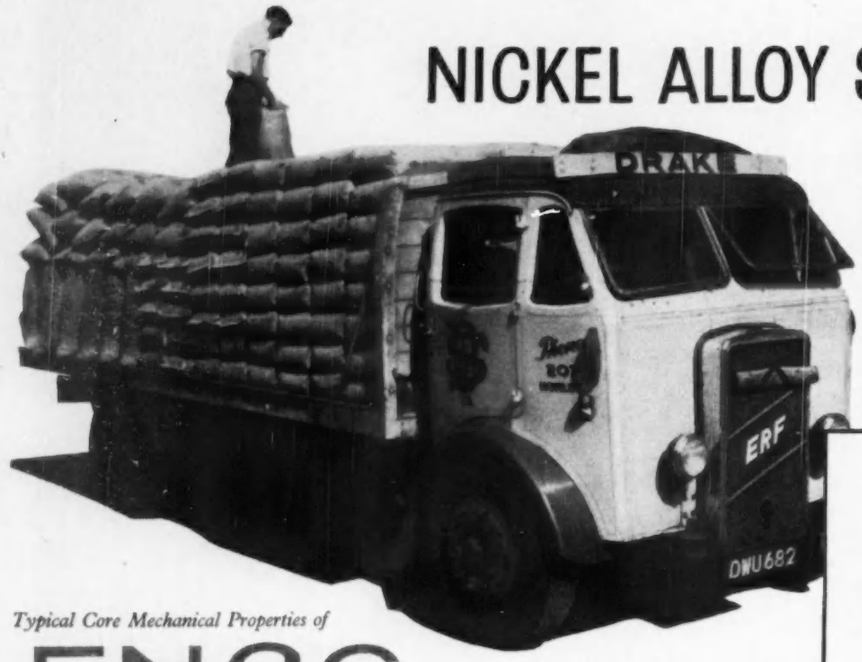

for long trouble-free mileage

Over a half-million miles and nineteen years of service have not impaired the efficiency of the David Brown gearbox fitted to this E.R.F. lorry operated by Samuel Drake and Sons, Ltd., Honley, Huddersfield. During a recent major overhaul after 582,000 miles of running, the gearbox was found to be in excellent condition and was replaced for further service, with a rebuilt engine.

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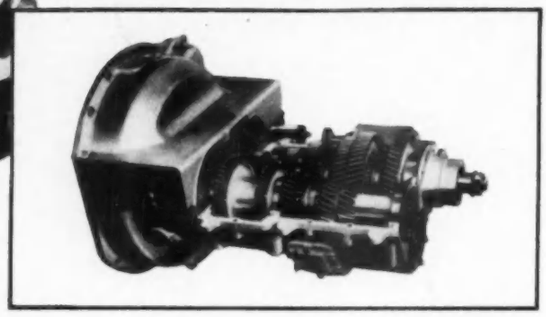

Typical Core Mechanical Properties of

EN36

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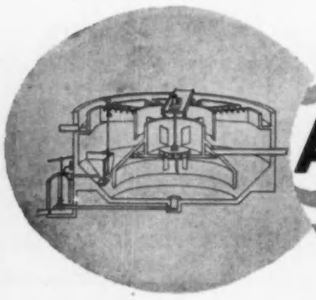

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THE ENGINEER

No. 5470 NOVEMBER 25, 1960 Vol. 210

INDUSTRY OR LANDSCAPE ?

The development of industry is capable of arousing very strong feelings. Let anyone propose, for however good a reason, the extension of industry into the country, and he will soon discover the existence of one strong feeling — opposition. Opencast coalmining has had its troubles in the past. Just now it is the turn of two other projects. One, well known (and not under attack for the first time), is the proposal to extend opencast iron ore mining in Oxfordshire. The other is a much smaller scheme, for reworking a former tin mine at Zennor in West Cornwall. Tin ore and iron ore have little in common except that they are both essential ores of commerce. One is produced by large-scale opencast mining and the other (in this country) by much smaller and less conspicuous underground mining operations. But both are attacked because they are said to be an ugly desecration of the natural charm and beauty of the countryside. The objection seems, on the face of it, reasonable enough.

In the heat of battle, however, the opponents forget one basic fact. Britain is an industrial country, and it is upon industry that our standard of living depends. That, incidentally, is something which the developing countries of the world never forget. They are expanding their existing industries and setting up new ones just as fast as they can. If we live in an industrial country we all share, more or less, in the benefits which industry confers upon the nation as a whole. The objectors to industry, no less than its supporters, all use or benefit in some way from such things as electricity, water supply and transport, to mention only a few of the essentials and to say nothing of the many near-essentials and luxuries which we all enjoy, and which all depend upon industry. If the objectors use any of these things they admit the need for industry and for the metals which are essential to it — metals which it must obviously have from where nature put them. No objector has so far come forward who is prepared, in his fight for the beauty of the landscape, to reject everything that industry has to offer and to live only on what he can win from nature. Indeed, almost all the protests contain somewhere the proposition "Let there be industry, but not here" — a statement which does its holders little credit. Tin ore can be obtained from several parts of the world and iron ore from many. Is there no natural beauty to be desecrated in those parts, or is it simply a matter of no importance?

There is, of course, a middle road; let industry develop as necessary, but see to it that the development is as inoffensive as possible. This is not a new idea. It has been put into very good effect in several parts of the country. Some of the land rehabilitation work carried out by iron ore mining companies in the east Midlands is a model of what can be done to minimise the effect of extracting a bed of mineral several feet thick. It is true that the replaced land surface is lower than it was, and that the old field divisions and hedges have disappeared. But if the land is different it is not necessarily worse. It is often forgotten that much that the objectors to industry wish to preserve unaltered is itself the work of man in past years. Because it is old is it automatically an "amenity"; did man always improve the land in the past? Equally, because a thing is new is it of necessity undesirable? Land rehabilitated after opencast mining might well be better than before. It is not unknown for such land to be more effectively drained than it had been, and more than one farmer has found it easier to mechanise his farm work in the new fields than in the old.

The tin mining project in Cornwall is a very different proposition. There the mining would be done underground, and all that is needed for this sort of operation is a relatively small group of buildings to house the hoisting and ore dressing machinery. With modern equipment there will be neither smoke nor smell, dust nor dirt — nothing but a few functional buildings. As the ore is in hard rock there is little or no risk of surface subsidence and the whole mine would be so inconspicuous that it is difficult to see how there can be any legitimate objection at all. It is a hard world in which we live, and we shall only make our way by facing facts. One of those facts is that industry must have its metals, and we should achieve nothing (except, if we were successful, our own ruin) by trying to stop it. But we can achieve much by helping industry to obtain its needs in a way which does the least possible harm. With proper safeguards the risk of harm is small. If past experience is any guide, our oft-maligned industrialists will be ready to co-operate.

LAND DRAINAGE AND WATER SUPPLY

A new Land Drainage Bill has come before Parliament so pat upon the occurrence of serious floods in several parts of the country that it may mistakenly be thought to have something to do with that flooding. In fact, of course, there is no direct connection. The Bill is, indeed, quite a minor affair. It gives more power to River Boards to levy drainage charges and it amends, and in certain respects widens, the powers of drainage authorities.

In the regions affected those who had the unpleasant and often dangerous experience accepted the flooding as an Act of God. Commentators pointed out, reasonably enough, that such high floods occur only once in a hundred years or so and that one cannot afford to expend much money on providing against the effects of a natural event which so rarely happens. But in that context consideration of the possibility of alleviating floods could profitably be linked with the similar consideration of the relief of droughts, such as that which afflicted this country the summer before last. Too much rain falling on this country in the last month or so following upon a wet summer and an usually wet autumn led to the occurrence of floods. Rather more than a year ago too little rain falling on this country throughout the summer and early autumn almost led to the disaster of depriving industry

of water in at least one industrial area, and in several rural areas and even some urban areas to rationing of domestic water supplies. The two conditions are linked together because what is a cure for drought—the provision of adequate storage capacity—is also a partial cure for floods.

Over the last very many years there has been a gradual increase in the demand for water for domestic and industrial purposes. But in the last two or three years the rate of increase has been quite dramatically pushed up in certain areas of Eastern England by the pumping of water direct from rivers for the irrigation of crops. A recently published report on the Great Ouse indicates that should such irrigation continue to expand then within a few years the whole flow of that river will be insufficient to meet the demand. No doubt the situation is similar in other catchments. For, whereas when water is used domestically or by industry an effluent is usually returned to the river, almost none of the water used for irrigation returns to the river. Nor will the building of reservoirs solely within the watershed of the Great Ouse suffice to store sufficient water. If demands for irrigation besides those for industry and for domestic purposes are to be met in the Great Ouse and other similar areas it will surely become essential to create a water grid so that water from rivers in regions of abundant rainfall may be stored in reservoirs above or below ground for the use of distant regions short of rainfall. Those who live in regions thus to be deprived of water which would otherwise have flowed down local rivers may well object. But the object of the proceeding should not be to deprive rivers in those regions of adequate summer flows but to store winter flood water, thereby relieving the region of destructive floods.

Water engineers can already foresee that some development of the character will become essential in the not distant future. But such a development is not possible so long as water is supplied, as at present, by many hundreds of separate authorities. A centralisation of water supply authorities is becoming more and more obviously sensible; and all the larger bodies so created ought to be placed under some unifying control for the purpose of creating a water grid. It is true that the need has been perceived at Government level, for the Minister concerned has for some time been encouraging amalgamations amongst water supply authorities. But in the view of many water engineers the Minister lacks a sense of real urgency. The floods of this autumn might have proved less destructive had it been possible to store some of the flood water against next summer's needs.

MACHINE TOOL DEMAND AND SUPPLY

As might well have been expected a number of references were made to the Mitchell report in the speeches which followed the annual dinner of the Machine Tool Trades association in London last week. But what was really more to the point in view of existing conditions was the direct appeal made by Mr. E. W. Field, the President of the Association, that industry should take advantage of the slack periods of the machine tool industry to purchase replacement machines. There were, he said, far too many machine tools now in service which had a lamentably lower production rate than their modern counterparts, to the detriment of their user's position in a competitive market. This is not the first time that such a suggestion has been put forward by the machine tool industry and the matter was carried further in Mr. R. W. Asquith's reply to a remark by the Hon. Geoffrey Rootes who said that the order lists for machine tools had grown so big with delivery dates stretching so far into the future that it was becoming increasingly difficult for the motor-car industry to plan ahead. Mr. Asquith said that to get the deliveries it wanted the motor-car industry should place orders much more quickly after reserving space and co-operate more closely with machine tool manufacturers.

The motor-car industry has in the past not been alone in criticising the machine tool industry for not being able to meet its requirements within a reasonable period. That there has been a measure of truth in this criticism is not to be denied, but it can hardly be expected of the machine tool industry that it shall extend its resources to meet peak demands over a period of only a few months and then for a long period have plant representing a large capital investment working well below capacity. We wonder how the motor-car or any other industry would react if it were asked to face such conditions. It would be ideal if all branches of industry using machine tools in large numbers could individually or collectively programme replacements and new plant to enable an even flow of production to be maintained by the machine tool manufacturers. Nor, it seems to us, should it be impossible to make a closer approach to that ideal than rules at present. After all, standard machines have a known economic life and the manufacture of new products is planned so well in advance that the early placing of orders should not prove an insurmountable difficulty.

This country's engineering industry is now facing probably the fiercest international competition in its history in striving to expand exports. Good machine tools, being the basic requirement for all forms of production, form the foundation upon which prosperity can be built up in that industry. For this reason the suggestion for an early appraisal by all firms of their existing plant, the preparation of replacement programmes to assist machine tool makers to make the fullest use of their capacity on a long term basis, and the earlier ordering of special production plant, is well worth the serious consideration of all manufacturing establishments.

CONTACTING THE UNCONSCIOUS

Now that the envied label of "sophisticated" is freely handed out to electronic circuits and other undeserving hardware, it is good to be reminded that the simplest human mind is an article of quite commendable elaboration. From a lecture given last week by Dr. Stephen Black to the annual convention of the Scientific Instrument Manufacturers' Association, we learned that its structure may be compared with that of a Neapolitan ice. The lower layers normally enjoy a quiet repose, which sounds an admirable prescription for the mind as a whole, while the top one is so battered by propaganda and the forces of public relations, so warped by the sinister pressures of the Establishment, as to be of very little use at all. However, in these bustling days nothing should be idle, and Dr. Black described how in suitable conditions the unconscious can be made to work, when it often acquits itself better than the conscious. Contact with the unconscious can be made by means of hypnosis, and this method has been used to obtain useful comment on the design of scientific instruments. Direct appeal to the conscious sometimes fails because the subject tends to accept an object simply because it has been made, influenced, perhaps by an ingrained respect for science and instrumentation produced by the barrage to which we have referred above. If, how-

ever, a subject who is receptive to deep hypnosis is allowed to handle a mock-up of a prototype for a short time, a sympathetic interlocuter may be able to extract more useful reactions. Success with this method depends on careful and prolonged cultivation of a *rapport* between the psychiatrist and his subjects. When this has been established, it is even possible, it is claimed, to induce in a subject the hallucination that he has operated a device for eight hours instead of a few minutes, and to assess the fatigue that would have been created by faults in design!

Dr. Black expressed a mild professional surprise at reluctance to "taking the layers off the unconscious" and declared that there was no evidence in the literature that hypnosis had ever done anyone any harm. The charm and wit of his exposition, aided by the after-lunch euphoria which descends upon conventions on the last day of business sessions, did much to carry his audience with him. The speaker was convinced that when the scientific history of this century comes to be written it will not be the discovery of nuclear power that will be the significant feature, but the application and acceptance of the sub-conscious mind in all aspects of man's activity. On the whole, however, our sympathies remained less with the pliant subject who, on being told to be deaf to a certain sound, obediently failed to hear the harmonics as well, than with the hard case who heard the lot on every occasion.

A PRIZE-GIVING WORTH REPORTING

All sorts of educational bodies hold prize-givings at various times of year. So do many engineering firms which provide training for apprentices, students and post-graduate pupils. We very seldom attend them and even less seldom mention them in our columns. For though such an affair is of intense interest within the community that makes up the body or firm concerned and of quite substantial interest to the locality in which it is situated the proceedings are of little significance to those who live elsewhere.

Every now and then, however, something occurs to throw a particular prize-giving into prominence. A famous man consents to give the prizes away; something much more memorable than usual is said; or for one reason or another the firm or one of the prize winners happens to be "in the news". Last week we went down to Bedford to attend the prize-giving held on Thursday, November 17 at the Queen's works of W. H. Allen and Sons Ltd. firstly because Sir Christopher Hinton was to present the awards and secondly for a more intriguing reason. Sir Christopher was schooled at Chippenham and apprenticed at the Great Western Railway works at Swindon — how large a number of outstanding engineers, many of them in fields other than railway work, first gained practical experience at Swindon! Then in 1923 young Christopher Hinton was especially selected for the award of the William Henry Allen prize of £1000 given, through the Institution of Mechanical Engineers, by the founder of the present firm. Good use he made of it! It took him to Trinity College Cambridge, where he gained first class honours in the Mechanical Sciences Tripos at the end of his second year, was Senior Exhibitioner of Trinity College in 1924 and 1925 and a Senior Scholar in 1926. There is no need to detail the remainder of his career except to recall that between 1946 and 1957 he was responsible for the engineering side of the work of the Atomic Energy Authority with headquarters at Risely. His name, for ever, will be connected with the development of nuclear power. What astonishes one about this history is not much the "success story" — after all the life-history of every prominent man is a "success story" — but the prescience of those who awarded the prize and who were able to see in the young apprentice, Christopher Hinton, the hints of greatness to come. No doubt William Henry Allen had a say in it — he certainly asked Hinton to come and see him at Bedford that autumn. But that may have been subsequent to the award. No doubt the young man had an excellent record ; was it so much better than the records of others ? How, we cannot help wondering, was so excellent a selection actually made?

But, lest anyone should assume upon reading this story that success came to Sir Christopher solely through the opportunity given to him to go to Cambridge, listen to his own words at the prizegiving. "What I learned at Cambridge undoubtedly enabled me to argue with scientists in my subsequent career at I.C.I., in the Ministry of Supply, and in the Atomic Energy Authority, and also to stop the scientists from blinding me with science. I am sure I could not have done that without the training which, as a result of the scholarship, I had at Cambridge. But I am quite sure, grateful as I am to your Founder for that scholarship, he would be the first to agree with me that it was not the three years that I spent at Cambridge which made me into an engineer — that made me perhaps a different and better sort of engineer — but the training that made me into an engineer was the training I got on the shop floor and in the Drawing Office at Swindon. . . . I think it is extremely necessary to point out to-day that engineering is not a science. Engineering is an art. In science there is only one unquestionably correct answer; there are very few problems of engineering where that is true. . . . A designer is never able to arrive at one single and correct solution to the problem of the design with which he is dealing. What he aims at doing is to arrive at the best compromise, and it is that which differentiates science from art." He went on to stress the importance of an adequate period of training in a works for mechanical engineers.

The Engineer—100 Years Ago (NOVEMBER 23, 1860)

"SKINNING METROPOLITAN BUILDINGS"

"At the present time this process is going on in various parts. Buildings of comparatively recent date have become so begrimed with soot and the beating of the weather, or are so decayed, that scaffolding has been erected, and the structures are in the way of being chiselled from top to bottom. The Scotch Church in Regent's-square, Gray's-inn road, has been treated in this way. It seems that about the eighth of an inch over the whole surface has been cut away, and now the front looks like that of a new building. Satisfactory as is the present appearance, it is not desirable this process should be often necessary. On another church, in this square, which has been erected about the same time as that just mentioned, an examination has been made of the portico and facings. The state of decay is remarkable. In some parts the flutings of the columns have entirely disappeared ; and in other parts the surface is rotten to a considerable depth. This rapid decay is a serious consideration. We ought to know more about stone than we do."

United Kingdom Oil Industry

By V. S. SWAMINATHAN, M.A., M.Sc.(Lond.).

Development of United Kingdom oilfields described and details of production outlined. There follows an analysis of the pattern of refining and a review of the recent progress made by the major oil companies together with a note upon the changing product demand. The expansion of the petroleum chemical industry is discussed together with other activities of the industry.

BRITAIN'S first industrial revolution was based on an abundance of energy provided by cheap coal. But additional power required now, and in the future in the new industrial climate, will have to come not from coal but from petroleum and nuclear energy (fission, fusion or thermo-ionic). Before atomic energy makes a significant contribution, the burden of providing the power for the nation's industrial expansion rests on oil, and the petroleum processing industry, largely built up in Britain since the end of the Second World War. Therefore, a recapitulation of the United Kingdom crude oil production, refinery expansion, progress of the petroleum chemicals industry, the changing pattern of consumption of products, shipbuilding with accent on tanker construction, the rapid growth of the oil equipment industry, and finally, research and development work leading to key patents, earning valuable foreign exchange, is in order.

TABLE I.

	1938 Million tons coal equivalent	Percentage	1948 Million tons coal equivalent	Percentage	1956 Million tons coal equivalent	Percentage
Coal	175·5	92·9	191·9	90·8	214·9	85·8
Oil	12·7	6·7	18·6	8·8	34·4	13·7
Water power	0·7	0·4	0·9	0·4	1·3	0·5
Total	188·9	100·0	211·3	100·0	250·6	100·5

In 1938 coal provided 93 per cent of Britain's inland energy needs; but since then the demand for power has risen as fast again as domestic coal consumption. These developments are indicated by the U.K. energy balance shown in Table I.

The total energy used in Britain in 1956 was equivalent to 251 million tons of coal, or five tons per head of the population. As far as oil is concerned, demand has been rising at more than 7 per cent annually since the end of the Second World War, and there is no reason to suppose that any slackening in the growth of consumption is in prospect over the next decade. The petroleum industry has contracts to supply the Central Electricity Authority this year (1960) with as much fuel oil as was consumed by the entire economy in 1955. By 1966 oil is reckoned to contribute nearly twice as much in terms of coal equivalent to Britain's energy intake as in 1956, implying a rise of from 14 to 21 per cent of the total.

Four years ago (in 1956) Mr. Aubrey Jones stated that Britain's energy consumption in terms of coal equivalent, which rose from 200 million tons in 1946 to around 250 million tons in 1955, would reach 300 million tons by 1965. At least 75 per cent of these needs would come from domestic coal and 3 per cent from nuclear power and hydro-electricity, leaving oil to supply 22 per cent (66,000,000 tons) of requirements. Mr. H. Cunliffe affirmed that the gap between the country's static coal supplies and growing energy needs, would be 50,000,000 tons in 1960 rising to 75,000,000 tons in 1975, or even 60,000,000 tons and reaching 125 million tons. He was of the opinion that it was to the nation's balance of payments advantage to import crude oil to fill as much of the energy gap as possible. Consumption of oil fuels is expected to go up from the 1955 level of 18·75 million tons to 34·5 million tons in 1960, an annual average increase of 13 per cent. The greater part of the burden is likely to fall on those liquid fuel products which could directly replace coal, and the expansion envisaged in this sector is from 7·75 million tons in 1945 to 21·75 million tons in 1960—an annual average rise of 23 per cent. In brief, the U.K. demands for petroleum products are reckoned to double over the next decade. A rule-of-thumb measure of new capital investment needed by the industry is that it costs up to £40 or more to step up capacity, in all phases of operation, from oil well to consumer, by 1 ton per annum. This virtual doubling of domestic oil intake in the coming ten years would entail an outlay of the order of £1000 million obtained mainly from the oil companies' retained profits.

The importance of abundant oil supplies to Britain is obvious. Already the gas and electricity undertakings are using oil power to supplement stationary coal production. Fuel and lubricants are only two among a multitude of needs met by petroleum and its derivatives. The marked increase in the production of sterling crude oil from the Middle East, and the phenomenal post-war expansion of petroleum processing capacity from 4·5 million tons in 1948 to over 39,000,000 tons in 1959 has gone far towards solving the problem of foreign exchange. British and Anglo-Dutch oil companies stand for more than a third of all petroleum entering international trade (excluding production and consumption in the United States and the Soviet Union which are largely self-sufficient in this strategic commodity). In the marketing field, they handle close on 50 per cent of the world oil trade, exclusive of the United States and the Soviet bloc.

OILFIELDS

Until the outbreak of the First World War the possibility of finding oilfields in the United Kingdom was neglected, but when the German submarine menace threatened supplies, a search for petroleum was sponsored by the Government. Only one minor well was discovered at Hardstoft in Derbyshire, and a single test well in Scotland gave encouraging indications of oil and gas. With the cessation of hostilities foreign oil supplies again became freely available, and search for domestic oil was brought to an end. Geological interest in the prospect remained, however, and led the Anglo-Iranian Oil (now British Petroleum) Company, Ltd. to suggest to the Government a simplification of the legal and administrative aspects for prospecting. The resulting Petroleum Production Act of 1934 vested in the Crown the ownership of all mineral oil not discovered until then, and rendered it feasible for a company to acquire exploration licences over large areas under attractive operating conditions. The Anglo-Iranian Oil Company, Ltd. working through its operating subsidiary (the D'Arcy Exploration Company, Ltd.) embarked on a major drilling programme, the first well being spudded in at Portsdown in January, 1936. Other concerns like the Anglo-American Oil (now Esso Petroleum) Company, Ltd., The Gulf Exploration and Steel Brothers, later joined in the search and drilled a number of wells. But the D'Arcy Exploration Company maintained its lead in the scale of its geological investigations, the number of areas tested and wells drilled, and finally discovered the Eakring field.

In 1938, following three years' search, gas was located at Cousland near Edinburgh and at Eskdale adjoining Whitby. The following year, Eakring, the first of the four Nottingham oilfields, and the shallow oil accumulation at Formby were discovered. During the Second World War the drilling campaign was intensified. The peak period was 1943, when 158 boreholes were drilled, of which 135 were producers.

During 1959 B.P. Exploration Company, Ltd. continued to search for oil, and, on behalf of the Gas Council of Great Britain, for natural gas. Exploration work was centred on the Carboniferous structures in the areas adjoining existing fields in the East Midlands, and in the Mesozoic formations of Southern England. The main targets in the former region were sandstones in the Lower Coal Measures and Millstone Grit series, with as secondary consideration the Limestone of the Lower Carboniferous. Further drilling was undertaken in the oilfields at Plungar and Egmanton, and a new pool was found at each. Development drilling was started at the new fields, Bothamsall, Corringham and Gainsborough. In the first property nine wells have been completed, eight of which had proved oil from the sandstones above the Millstone Grit by October, 1959, and several more were completed during the last quarter of the year. At Corringham and Gainsborough one further well at each field found oil in Sandstones in the Coal Measures and at other horizons down to Kinderscout Grit about 700ft below the top of the Millstone Grit. In addition, one dry hole was drilled at Corringham, and one that proved the presence of gas only, at Gainsborough. Three exploration wells were completed in the Carboniferous area during the year at Bingham, Walkeringham and High Marnham. Bingham gave indications of oil but of insufficient quantity for commercial production, while Walkeringham depicted several non-commercial gas shows. In the Mesozoic area of Southern England exploration was continued at Radipole, Langton Herring, Bere Regis and Kimmeridge. At Kimmeridge oil came from the Cornbrash Limestone in the Middle Jurassic at a depth of 1760ft. Prolonged testing is in progress, and meantime, further wells were drilled to investigate the accumulation. The other South of England boreholes were dry. Britain's crude oil production and exploration activities are found in Table 2 and the accompanying map.

TABLE II

Name of Field	Year of Discovery	Proved Surface Acres	Average Producing Depths (feet)	Number of Wells: Pumping	Shut in	Drilling during July	Production (BBL): Daily Average first six months	Accumulative discovery to July 1	Gravity API or Specific	Geological
Formby	1939	20	85/130	10	—	—	0·2	72,800	0·853	Keuper
Eakring	1939	200	1800/2500	37	—	—	15·2	1,988,400	0·856	Millstone grit
Duke's Wood...	1941	400	1800/2500	106	—	—	51·0	3,756,300	0·856	Sandstone
Kelham Hills...	1941	350	2000/2500	41	—	—	21·8	1,842,600	0·885	Sandstone
Caunton	1943	60	2000/2200	10	—	—	3·3	247,600	0·885	Sandstone
Plungar	1953	250	2800/3080	8	—	—	11·1	125,100	0·871	Sandstone
Egmanton ...	1955	1,050	3100/3400	35	—	1*	103·7	709,500	0·827	Sandstone
Langar	1957	—	2730/2750	—	1	—	—	600	—	Sandstone
Bothamsall ...	1958	—	3170/3350	6	—	2	7·4	15,200	0·821	Coal Measures, Millstone Grit
Corringham ...	1958	—	4370/5250	2	—	2	3·6	7,800	0·8285	Coal Measures, Millstone Grit
Gainsborough	1959	—	4620/5280	1	—	—	2·1	2,900	0·8285	Coal Measures, Millstone Grit

	Wells Completed First Half of Year: Total	Oil	Gas	Dry	Estimated Completion Last Half of Year: Total Footage	Total	Total Footage
Wildcat (exploration)	7	2	—	5	23,370	5	10,380
Development	11†	6	—	2	40,130†	20†	76,350†

* Water injection well. † Includes three water injection wells.

REFINERIES

The immediate post-war programme of U.K. refinery construction was virtually completed some time ago, but no petroleum processing plant in fact is ever "complete," since in no other industry does process and plant devlopment follow research and the dictates of demand so closely and quickly.

Since the demands for the various products of refining bear no relation in general to the proportions of the items which can be obtained from crude oils by physical separation alone, the refiner must process the primary fractions to procure products in quantities demanded by the market to stay "in balance." The processes available fall into three main classes: (1) separation processes (distillation and solvent treating); (2) breakdown processes (catalytic cracking and coking); and (3) quality improving processes (reforming, edsulphurisation and viscosity breaking). The lightest crudes in general contain the greatest proportion of the low-boiling components, like petrol, kerosene and diesel oil and are the dearest. The average Persian Gulf petroleum yields the following main fractions: petrol 23 to 26 per cent., gas oil 37 per cent, and fuel oil 37 to 43 per cent. A refinery, which is able to break down the heavy fractions to lighter products, can thus process the cheaper crudes more profitably.

In Britain the pattern is such that a minimum of breakdown is desirable. In fact, the trend suggests that to satisfy the demand for fuel oil in the future it may be necessary to charge heavier crudes, and to import fuel oil if excess production of petrol is to be avoided. The accent is also progressively on higher octane petrols, and for lower sulphur content middle distillates. The British refiner must rely on upgrading the petrol components already present in the crude oil. The petrol fraction from the crude oil is split into a light and a heavy fraction. The latter is upgraded by catalytic reforming, in which the main octane improving reaction is dehydrogenation of naphthenes to aromatics, which have high octane numbers. The light fraction is usually already fairly high in octane rating, and low in naphthenics content. It is, therefore, uneconomical to reform this fraction catalytically, and it is normally blended with the reformed naphtha without such treatment. The increased British demand for fuel oil, if it leads to processing heavier crudes, may help indirectly in meeting the octane requirements of petrol. The heaviest Middle East crudes yield naphthas high in naphthenics, which are the principal source of the octane improvement on catalytic reforming. Even so, the demand for higher and higher octanes will probably compel the U.K. refiner to employ such processes as thermal reforming of catalytic reformates and isomerisation of the light straight-run petrol. An important result of this octane uptrend, and the consequent widespread use of catalytic reforming, is the availability of large quantities of hydrogen. This has led to extensive use of hydrogen-treating for a great variety of products, both final and intermediate—desulphurisation of naphtha charge to reforming, desulphurisation of diesel and gas oils, upgrading of cracked products, hydrotreating of lubricating oils and hydroforming of catalytic cracker feedstock.

Turning to recent progress registered by major British companies, we start with the British Petroleum Company, Ltd. Expansion work at the Kent and Grangemouth refineries was completed early in 1959, raising the total refining capacity of this group in the United Kingdom to 13·2 million tons a year. Projects completed during the past two years increased the annual throughput capacity of the Kent refinery from 4·4 to 7·1 million tons, and that of Grangemouth from 2·2 to 3·1 million tons, while the capacity of the Llandarcy refinery in South Wales has been maintained at 3,000,000 tons per annum. The Kent refinery, of which a general view is included, was commissioned in 1953, and expansion since then has increased the total investment from £30,000,000 to £85,000,000. This included the erection of a second crude distillation unit, the installation of a specialist plant for the manufacture of aviation spirit, with a capacity of 130,000 tons per year, and units for the production of low sulphur gas oil. Main items of the new expanded plant are a 90,000 b/d crude distillation unit, including side stream soda washery and other ancillary facilities; a 10,000 b/d. thermal reformer; a 10,000 b/d. catalytic reformer; a 2250 b/d. alkylation unit; two hydrofiner units each of 10,000 b/d., and a 12,000 b/d. stabiliser. In addition, two new jetties were built on the Medway to accommodate large tankers, and an extension effected to the lubricating oils jetty and construction of a new one for coastal craft.

The Grangemouth refinery in Scotland started a second crude distillation unit of 1,800,000 tons per year capacity. It formed part of the £6,000,000 programme to raise crude oil throughput to 3·1 million tons after the scrapping of obsolete plant. In 1959 several ancillary processing units were commissioned, and additional tankage completed. This plant can be fed by tankers

A—CARBONIFEROUS PROSPECTS
Oil and gas shows in outcropping rocks and in workings and borings of oil shale field.

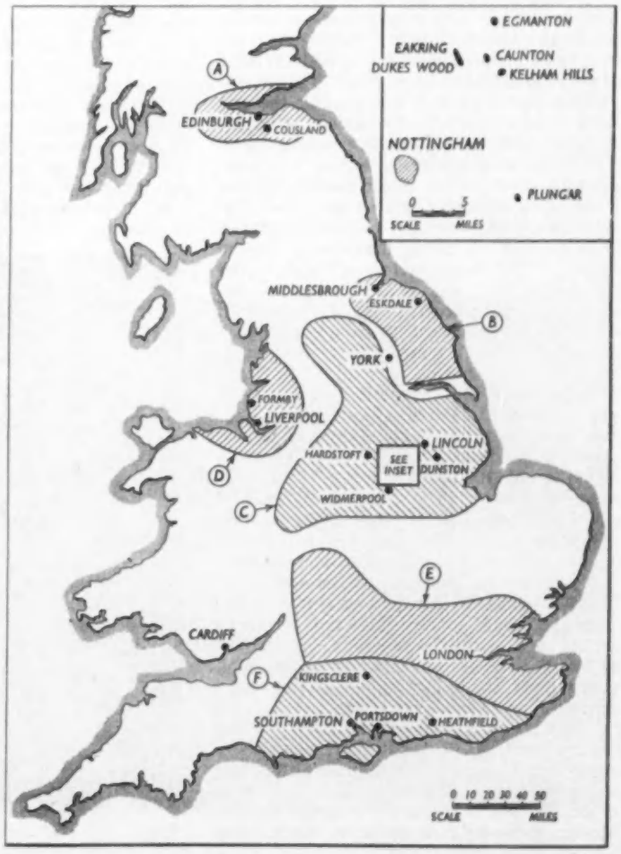
B—PERMIAN PROSPECTS
Evidence of oil and gas in boreholes and outcropping rocks.

C—CARBONIFEROUS PROSPECTS
Oil in Carboniferous Rocks, in outcrop, in boreholes and in mines. Oil in Carboniferous Limestone in Hardstoft No. 1 and Plungar No 2.

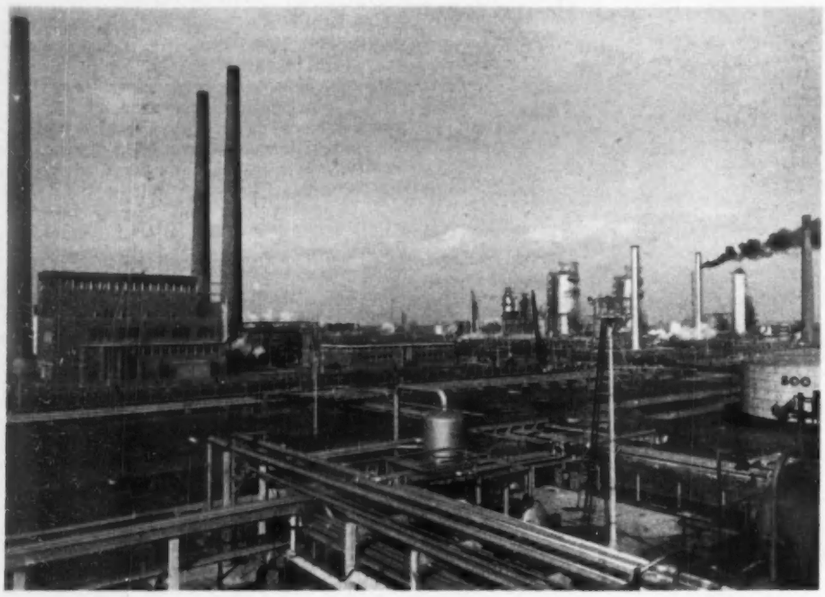
D—CARBONIFEROUS PROSPECTS
Strong oil seepages in *Peat near Formby*. Small oilfield in Trias Rocks near surface.

E—PALAEOZOIC PROSPECTS
Occasional shows of gas in boreholes.

F—MESOZOIC PROSPECTS
Oil impregnated sandstones, etc., of Jurassic and Cretaceous age outcropping along coast. *Gas at Heathfield (Sussex).*



Map of prospecting areas



General view of Kent oil refinery

carrying up to 100,000 tons of crude oil. In June, 1959, a new jetty capable of berthing the largest tankers at any state of the tide, was officially opened at the Finnart ocean terminal on Loch Long and is linked with the Grangemouth refinery by a 57-mile pipeline. Building of the new Finnart jetty, with associated storage tanks and other installations, entailed an expenditure of £2,000,000. Tankers can now discharge at a rate of 6000 tons per hour of crude oil at this jetty.

The building of the new oil tanker terminal to feed the Llandarcy refinery was completed at Angle Bay on Milford Haven, and is shown under construction in the accompanying illustration. The 60-mile pipeline, with capacity to carry 5,000,000 tons per year of oil from Angle Bay to the refinery was for the most part complete at the end of last year. At the jetty two of the largest tankers will be able to unload simultaneously. They will discharge their cargoes by means of their own pumps direct into a transfer pipeline, connecting with a tank farm and one electrically-operated pumping station pumps crude oil along the pipeline to the refinery. The main sector of Popton Fort at Angle Bay was reconstructed as the administrative offices for the terminal, and an outer part excavated to accommodate tanks for ships' bunker fuel and water supplies.

Apart from the commissioning of the petroleum chemical plant, illustrated on page 869, at Fawley, in May, 1958, the major additions made to other processing units by the Esso Petroleum Company, Ltd., was the powerformer. This processes 21,000 b/d. of virgin naphtha, and produces a high octane petrol component, and cost £4,300,000. It has Britain's largest carbon monoxide boiler, designed, manufactured and installed by Babcock and Wilcox, Ltd. It utilises the flue gases rich in this material produced during the catalytic cracking process to generate 300,000 lb steam per hour at a pressure of 150 lb per square inch, and a temperature of 465 deg. Fah.

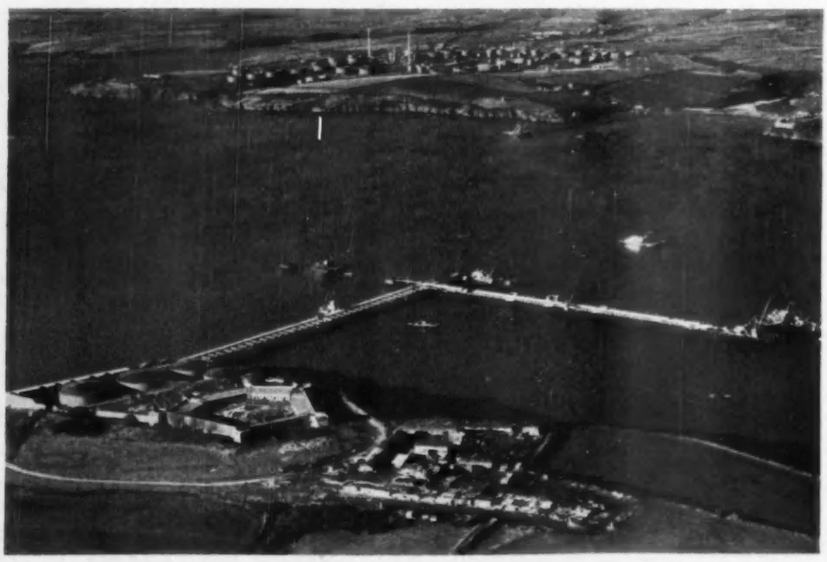
The 4·5 million tons per year Esso Milford Haven refinery, of which a photograph is reproduced, was described in THE ENGINEER of November 18. It operates on Middle East crude oil, and accounts for propane, butane, petrols, turbo-jet fuels and auto diesel. The furnace of the 100,000 b/d. pipestill has a heat output of 500 million B.Th.U's per hour. This Esso refinery has both hydrofiner and powerformer units. Its jetty is capable of accommodating two 100,000-ton tankers, and a 5000 ton ship simultaneously.

A new Udex plant for the production of an important constituent of aviation petrol was commissioned at Stanlow operated by the Shell Petroleum Company, Ltd. in 1958 at a cost of £800,000. Work was completed on the 25-mile pipeline from Stanlow to Carrington, which enables fuel oil, gas oil and petrol to be moved from Stanlow to a new Shell-Mex and B.P. depot at Carrington. Other lines transfer feeding stocks to Petrochemicals, Ltd. at Carrington, and ethylene, ethane, propylene and other gaseous products to Stanlow. The new crude oil berth and shore installation for the handling of supertankers at Tranmere 9 miles from the refinery and the pipeline to Stanlow was completed this year.

At Shell Haven the commissioning of a second 110,000 tons per day unit has raised the capacity of this refinery to 8,000,000 tons a year. It incorporates a high degree of heat recovery, so that fuel consumption is some 30 per cent less than in the previous design. Other new plants now operating include a 2400 tons per day hydrodesulphuriser for the removal of sulphur compounds from Middle East gas oil by the Shell " trickle-phase " technique, using the hydrogen from the adjacent platformer. On page 870 is a general view of the platforming plant. The sulphur compounds are eliminated as hydrogen sulphide, yielding 20 tons per day of pure liquid sulphur. Then, there is a 600 tons per day blown bitumen plant. Also, two 1500 lb per square inch gauge high-pressure boilers, and 10,000kW turbines, were completed early in 1959.

Additions and modifications made to the two-stage crude distillation unit at Coryton, belonging to the Mobil Oil Company, Ltd., have increased its capacity by 20 per cent to 1,850,000 tons per year. When modifications to the propane de-asphalting unit and methyl ethyl ketone de-waxing units were effected late last year, the potential of the refinery to produce lubricating oil base stocks was augmented. The lubricating oils manufacturing units are shown on page 870. The new liquid petroleum gas (L.P.G.) plant designed to produce 21,000 tons per year of butane and 12,000 tons per year of propane from refinery tail gas, and facilities for storage and distribution of products, was erected by Constructors John Brown, Ltd., from designs provided by the Process Design Group. Over 200,000 barrels of additional tankage have been built, and a further 174,000 barrels of crude storage tankage was completed later. Also, a major extension to the barge loading jetty has been made, and the berth at No. 3 jetty dredged to enable it to take 48,000-ton tankers alongside.

Mr. W. K. Hutchinson, in a presidential address given to the Institution of Chemical Engineers, offered these comments on " Fuel and Power—A Technological Approach." He stated that oil refineries are operating at efficiencies between 91 to 95 per cent depending on the complexity of the process involved; the capital cost can be estimated as of the order of £5 per therm of daily output on a scale of 5,000,000 tons of oil a year. He also recapitulated the efficiency factors



Oil terminal at Angle Bay, Milford Haven

Petroleum chemicals plant at Fawley Refinery

distinguishing three methods of processing fuels—namely, oil refining, gas production by the Lurgi process with L.P.G. enrichment and electricity generation at a thermal power station :

	Oil refining	Gas production	Electricity generation
Scale of operation : Therms per day ...	5,000,000	500,000	440,000
Electrical units ...	—	(600MW)	(550MW)
Processing efficiency	91–95 per cent	73 per cent	36·5 per cent
System load factor ...	—	75 per cent per therm	45 per cent per therm
Capital cost	—	£34	£49
Adjusted for load factor including storage	£5	£59	£104
Cost of transmission : 100 miles at 5 per cent load factor	(L.P.G. 0·32d.)	1·3d.	4·1d.

The substantial outlay of American-controlled oil companies has proved an asset to the British economy, and at the end of 1957 the net assets of such corporations were worth 394 million dollars, equivalent to 20·7 per cent of all the U.S. direct capital holdings in the U.K. Apart from the increase in fuel supplies made available, of the order of 15,000,000 to 18,000,000 tons of coal equivalent a year, and the saving in foreign currency exceeding 100 million dollars per annum by Esso Petroleum Company, Ltd. alone, five major contributions deserve mention. The petroleum equipment industry has received a stimulus both from the volume of orders placed by the oil companies, and the technical knowledge made available by them and their constructional and design engineers. Following enhanced demand for oil transport over half the output of British merchant shipping in recent years has taken the form of tankers. The two U.S. oil refining companies are important foreign exchange earners—Esso exported £13,500,000 worth of petroleum products in 1957, while Mobil Oil accounted for 25 per cent of British exports of lubricating oils and greases. This American investment enabled several important new technical processes and products to be introduced into this country more speedily than would otherwise have been the case. Typical examples include the production of high octane petrol by hydroforming, fluid catalytic cracking, the "Thermofor" continuous percolation unit for the filtering of oils, the new synthetic lubricants and anti-icing additives for motor fuel, and conversion of low octane naphtha into high octane petrol by the catalytic reforming unit, using a platinum catalyst. Above all, there was the impetus given to the development of the British petroleum chemical industry following the general expansion of petroleum processing capacity in Britain.

The establishment of domestic refineries has determined the pattern of economic and efficient distribution and marketing of oil products. The distribution from British petroleum processing plants is based on handling products in as large volumes as possible and reducing the number of intermediate stages to a minimum, for it has been estimated that for each intermediate step the cost of delivery of motor spirit goes up by approximately 20 per cent.

Both the total consumption and the relative importance of the products have altered greatly in recent years. Whereas in 1938 motor spirit accounted for well over half the total inland trade of the British Isles of around 9,000,000 tons, and gas-diesel and fuel oils less than one-sixth ; in 1959, out of a total consumption (ex-refinery use) of over 33,000,000 tons, gas-diesel and fuel oils accounted for virtually one-half, with motor spirit less than one-fourth of the total. The growth in consumption of fuel oil has been outstanding—the most spectacular advance being in steam raising. Thus, the intake of fuel oil at power stations in 1959 was over 4,000,000 tons. Something like two-thirds of the steel made in Britain to-day is produced in liquid fuel-fired furnaces. Central heating is another rapidly expanding outlet. Similarly, a widening range of industries is using the distillate oil for central heating and power purposes.

Petroleum and gases have now become the preferred raw material source for Britain's organic chemical industry, and, compared with other sources, crude oil and natural gas offer the possibility of making a greater diversity of primary chemicals. This raw material is in steady and abundant supply, presenting a fast-growing industry with a more stable cost basis, and is easy to transport and handle. Although the initial capital investment is generally on the high

View of the Milford Haven Refinery looking North

side petroleum still represents a reasonably cheap basic source. Natural products, like plantation rubber which is variable both in availability and price, are likely to be replaced by synthetic products.

It so happens that in the United Kingdom several large oil refineries built since the Second World War are in districts where important markets for chemicals already exist, and by constructing chemical installations alongside petroleum processing plants, the twin advantages of proximity to the source of raw material and easy access to major outlets are obtained. Examples are the Shell Chemical Company's installation at Stanlow on Merseyside, and British Hydrocarbon Chemicals' plant at Grangemouth on the Firth of Forth. By way of contrast, Monsanto and Union Carbide sited some of their plants adjacent to Esso's refinery at Fawley on Southampton Water. Although these units are not in an important industrial area they enjoy a coastal location, and are not far from Greater London. The I.C.I. complex at Wilton on the Yorkshire coast, is not adjacent to a refinery, but it was sited with other considerations in mind.

During 1950–57 the growth rate of organic chemicals was 40 per cent per annum, compared with a 6 per cent annual growth rate for the entire chemical industry, and 3 per cent for the industry as a whole. In the next few years the most rapid expansion in organic chemicals is envisaged in plastics, and synthetic fibres.

Britain's cumulative capital investment in petroleum chemicals through 1948–58 was £103 million, of which £90,000,000 was in organic, and £13,000,000 in inorganic chemicals. Output of oil-based chemicals rose from 184,000 tons in 1952 to 634,000 tons in 1958 (organic chemicals from 148,000 to 474,000 tons, and inorganics from 36,000 to 160,000 tons). The organic chemicals fall into these broad general groups: (1) chemical solvents for paints, lacquers, &c.; (2) synthetic detergents, both powder and liquid; (3) plastics like polythene, polypropylene, P.V.C. and polystyrene; (4) synthetic fibres such as nylon and "Terylene"; (5) synthetic rubbers like styrene-butadiene; (6) pesticides, insecticides and fungicides; and (7) chemical products for use in the oil industry, like petrol additives and ethylene glycol, or anti-freeze. In the inorganic sphere, both I.C.I. and Shell Chemicals are producing ammonia making use of hydrogen obtained from petroleum. The main outlets of the product are in the manufacture of nitrogenous fertilisers and nitric acid. Sulphur contained in crude oil, mainly of Middle East origin, is removed in the course of refining operations at several U.K. refineries, and is recovered as elemental sulphur, or in the form of sulphuric acid.

In 1960 in the petroleum chemicals sector alone the combined value of the manufacturers' investment is reckoned to increase by £65,000,000 to a total exceeding £140 million. Two new but related projects were announced last February: the first stage of the planned Severnside works of I.C.I., and to provide the main raw material for this project the Esso Petroleum Company is installing at Fawley a new installation and linking it by pipeline with the new I.C.I. works.

Oil pipelines have not hitherto been a feature of British communications except those constructed during the war to save the hazardous tanker voyages. For economic rather than for strategic reasons the transport of oil products from refineries to areas of consumption is now being effected by pipelines, instead of by road or rail tankage in particular areas. As already mentioned Shell Petroleum, Ltd. has completed a project connecting the Stanlow refinery with the Carrington Chemical Works near Manchester and a depot at Partington by a system of pipelines. If, as this concern believes, the large initial cost of the pipeline can be offset by long-term savings on road and rail transport, the system may be extended to other parts of the country. A 9-mile long jet fuel pipeline for delivery of aviation fuel to the London Airport was commissioned last March. Also, Esso Petroleum Company is spending £2,500,000 on the construction of a 75-mile petroleum products pipeline from its Fawley refinery to a new distribution depot adjoining the London Airport. It will be the first large-scale products line in Britain and it is scheduled for completion early in 1963.

Other salient points pertaining to the British petroleum industry are that it had already built up an export trade in refined products and chemicals and that there is the growth of the sterling oil companies' production of the world trade with all that means to the sterling area's balance of payments, while the revenue derived from hydrocarbon duties is not to be despised. Moreover, Britain has a new and expanding industry concerned with oil equipment and materials. Finally, research and development work undertaken by local companies has led to key patents relating to autofining and hydro-desulphurisation processes and production of polythene and "Terylene," thus earning valuable foreign exchange.

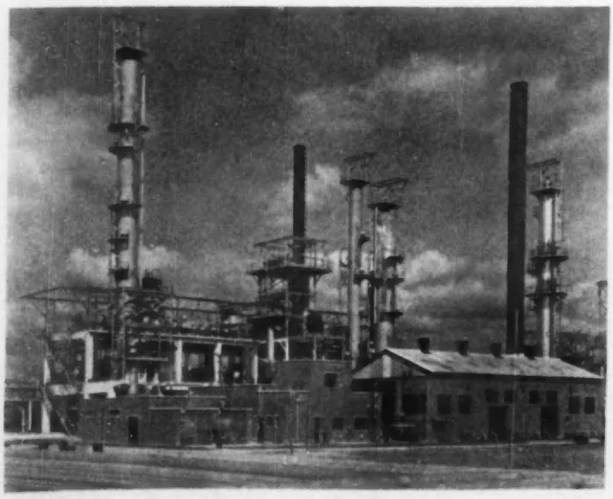
In conclusion, the United Kingdom, obtaining 30 per cent of its national income from foreign trade, is not unfamiliar with political risks associated with international specialisation. There is, however, the question whether Britain can afford to rely increasingly on overseas supplies of oil. The real answer is that she traditionally has earned her living by specialising in the things she can do better than other nations and by trading them for the commodities which others can provide more cheaply, or which are not found locally. Britain is short of half her food requirements and two-thirds of her raw materials including oil. This simply means that she has a higher stake than most in the free and unfettered growth of world trade since it offers the expanding markets needed by her exporting industries.

TABLE III

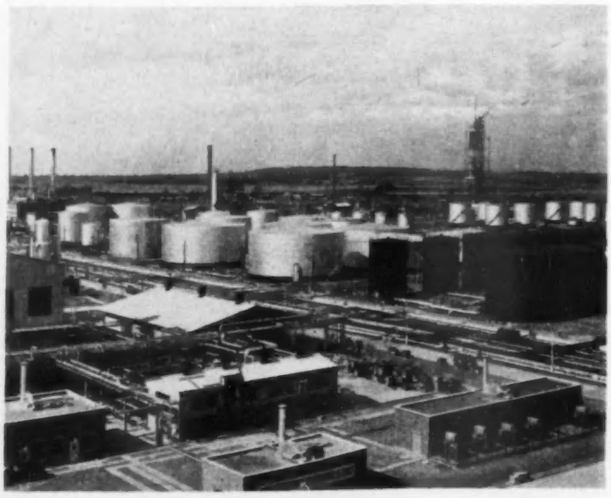
Organic Chemicals from Petroleum in U.K.

Year	No. of Petroleum Chemical Plants in operation	Year-end Capital Investment £ million	Liquid Feedstocks Consumed (1000 metric tons)	Refinery Gases Consumed (1000 metric tons)
1953	5	39	479	85
1954	7	43	558	104
1955	7	45	571	157
1956	8	61	618	164
1957	9	76	873	170
1958	12	90*	1,055†	206†
1960	15	141	1,336†	—

* Approximate. † Estimated.



General view of platforming plant



Processing units for the production of lubricating oils

THE ENGINEER

Technical Contributors Section

NOVEMBER 1960

Temperature Measurements in a Doxford Cylinder Liner

By B. W. MILLINGTON, B.Sc., A.M.I.Mech.E., A.F.R.Ae.S.

This article describes the results of a short survey of the temperature distribution in a cylinder liner of a Doxford marine engine. The survey formed part of a general investigation being made by the British Shipbuilding Research Association into the problems of operating marine engines on residual fuel. The most important problem is that of increased liner and ring wear, which may be attributed either to corrosive attack arising from the increased sulphur content of the residual fuel or to abrasive attack due to the higher ash content of the fuel. In studying this it is important to know the temperatures of the metal surfaces exposed to the combustion gases because these temperatures will control the tendency to condensation of the acid products arising from combustion of the sulphur in the fuel. The survey showed the temperature of the bore surface of the Doxford engine to be relatively low. As a result, condensation of the combustion acids is probable and corrosion is likely to be of importance in the mechanism of liner wear in this engine. The survey also provided information regarding temperature gradients and local rates of heat flow in the liner, a field in which available data is scarce.

IN the immediate post-war years it became apparent that it would be an economic necessity for the majority of marine propulsion diesel engines to operate on a lower grade of fuel than the marine diesel fuel used at the time. By about 1954 the use of residual fuel had become quite common and many of the problems of handling, cleaning and injection of the fuel had been worked out on a satisfactory basis. However, a major problem remained ; this was the increased rate of wear of liner, piston and rings when using residual fuels. The British Shipbuilding Research Association, the central research organisation of the shipbuilding industry, recognising this problem, initiated a number of research projects with the object of studying the mechanism of this high rate of wear. The Ricardo Engine Test Laboratory at Shoreham has been carrying out certain of these investigations on behalf of the B.S.R.A. and the material of this article was obtained during the course of this work by the staff of Ricardos.

There are two properties of residual fuel which may give rise to high rates of wear : first, there is the high carbon residue and ash content which can result in abrasive debris being formed during combustion and, secondly, there is the high sulphur content of the fuel which may result in the production of sulphuric acid within the engine and therefore the likelihood of corrosive attack on the internal surfaces. In studying the mechanism of wear it is important to attempt to establish the relative importance of these two modes of attack. The temperature of the internal surfaces of the combustion chamber space and cylinder walls controls in a large measure the tendency to condensation of the acid products of combustion upon them which, in turn, controls the likelihood of wear by corrosive attack. It is therefore of importance to know the temperature of these surfaces in estimating the relative importance of corrosive and abrasive wear. There are very few data indeed available relating to the distribution of temperature and temperature gradients in engines of any size, and this is particularly so in the case of large marine engines. However, William Doxford and Sons, Ltd., very kindly made available a single-cylinder unit which enabled a short series of measurements of the temperature of the liner and of the temperature gradients through the thickness of the liner to be made.

Object and Scope of the Tests

By means of traversing thermocouples at a number of stations along the whole length of the liner, the temperature gradient through the liner was measured at each station. This enabled two deductions to be made : first, by extrapolation of the observed gradient to the internal bore surface the temperature of the surface could be estimated and, secondly, the local heat flow across the liner could be calculated from a knowledge of the thermal conductivity of the liner material.

By this means a complete picture of the temperatures within the liner was built up over the whole load and speed range of the engine.

Test Equipment

The engine used for these tests was a single-cylinder Doxford engine installed at the Palmer's Hill works of William Doxford and Sons, Ltd., and used by them for general development work. The engine was the 670mm bore, opposed-piston, single-acting, two-stroke, the stroke of the exhaust piston being 980mm and that of the scavenge piston 1340mm. It had been converted to the "diaphragm" type of construction and also employed the latest type of fuel-injection system.[1] Scavenging was by lever-operated scavenge pump ; the unit was not turbo-charged.

Table I—*Inspection Data of Fuel*

Test	Method*	Results
Specific gravity at 60 deg. Fah. ...	I.P.59	0·9635
Total sulphur, per cent weight ...	—	3·90
Viscosity kinematic at 100 deg. Fah. cs	I.P.71	354·96
Viscosity Redwood 1 at 100 deg. Fah. (calc.), second	—	1446·0
Carbon residue, per cent weight ...	I.P.13	8·72
Asphaltenes, per cent weight	I.P.143	1·65
Ash, per cent weight	I.P.4	0·140
Water and sediment, per cent volume	I.P.75	0·20

* "Standard Methods for Testing Petroleum and its Products," Institute of Petroleum, 1955.

The fuel used throughout the tests was a residual fuel having a viscosity of 1500 second Redwood No. 1 at 100 deg. Fah., further inspection data are given in Table I. Cylinder and crankcase lubricant was Shell Talpa 30.

The material of the liner was a vanadium-titanium cast iron of the nominal composition given in Table II. A sample of this liner was not available for analysis, but a specimen from a similar liner was obtained in order to determine the thermal conductivity of this type of iron. Measurements by the N.P.L. showed that this material had a thermal conductivity in the temperature range 50 deg. to 200 deg. Cent. of 0·53 joules per square centimetre per second for 1cm thickness and 1 deg. Cent. difference in temperature ; this is equivalent to 0·127 c.g.s. units.

TABLE II—*Composition of Cylinder Liner*

	Percentage
Total carbon (graphite 1·85, combined 1·07)	2·92
Silicon	0·97
Sulphur	0·063
Phosphorus	0·47
Manganese	0·79
Nickel	0·17
Copper	Trace
Chromium	0·12
Molybdenum	Trace
Titanium	0·05
Vanadium	0·17

Temperatures were measured by means of Ricardo traversing thermocouples, the original design has been described elsewhere,[2] but a more robust and simplified design was employed for the present tests, and is shown in Fig. 1.

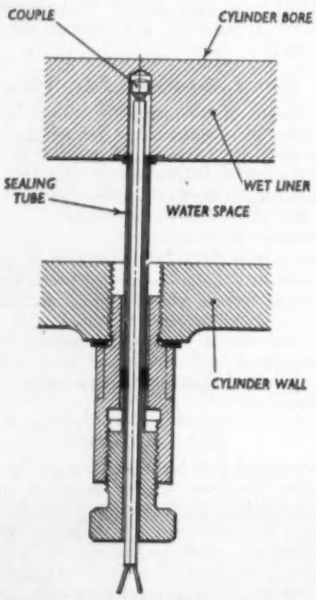


Fig. 1—Traversing thermocouple

The hot junction of the thermocouple consists of a short copper plug of $\frac{1}{16}$in diameter, into which the chromel and alumel wires of a length of Pyrotenax tube are brazed. The copper plug is a slide fit in a hole drilled through the liner to within a short distance of the inner wall. The thermocouple is carried through the water jacket in a sheath with small rubber sealing washers at each end to prevent the ingress of water to the thermocouple hole. The thermocouple may be traversed in the course of a test, its position being indicated by a simple scale at the outer end of the couple.

The Doxford cylinder liner was drilled at twelve positions on or as near as possible to the front centre line of the cylinder and a traversing thermocouple was fitted at each position. These stations are shown in Fig. 2

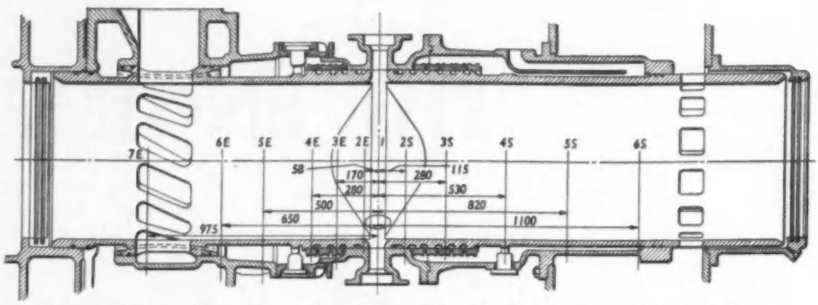


Fig. 2—Axial positions of heat flow thermocouples. Doxford 670mm × (1340 + 980)mm

TABLE III—*Doxford Single-Cylinder Engine, 670mm×(1340+980)mm. Thermocouple Positions and Data*

Thermocouple No.	Distance from injector centre line, mm	*T*=traversing *F*=fixed	Positions of temperature readings, mm from bore*	Liner thickness, mm	Remarks
7E	975	*T*	6 18 30 42	50	—
6E	650	*T*	6 10 14 17	25	—
5E	500	*F*	7	25	Short hole
4E	280	*T*	6 10 14 17	25	—
3E	170	*T*	6 10 14 17	25	—
2E	58	*T*	6 10 14 17	25	—
1	0	*T*	6 10 14 17	25	—
2S	115	*T*	6 10 14 17	25	—
3S	280	*T*	6 10 14 17	25	—
4S	530	*T*	6 11 16 22	30	—
5S	820	*F*	4·5	25	—
6S	1100	*F*	4·5	25	Liner very hard

* These positions are based on the assumption that the temperatures recorded are those at the leading edge of the thermocouple.

TABLE IV—*Doxford Single-Cylinder Engine, 670mm×(1340+980)mm. Test Conditions*

Test No.	Symbol	R.p.m.	B.m.e.p., lb per sq. in	B.h.p.	Specific fuel consumption, lb per b.h.p. per hour	Gross fuel consumption, lb per hour	Exhaust temperature, deg. Cent.	Jacket water temperature, deg. Cent.		Oil temperature, deg. Cent.	
								In	Out	In	Out
1	×	110	71·3	989·5	0·395	391	297	52	62	43	56
2	○	98	53·5	659·0	0·391	258	213	56	63	38	47
3	⊡	78	33·7	331·0	0·42	139	152	57	63	37	42
4	△	56	17·7	124·8	0·488	61	104	57	62	39	42
5	+	109	47·8	656·0	0·406	266	215	54	63	40	51
6	▽	75	69·5	656·0	0·378	248	249	54	63	43	51

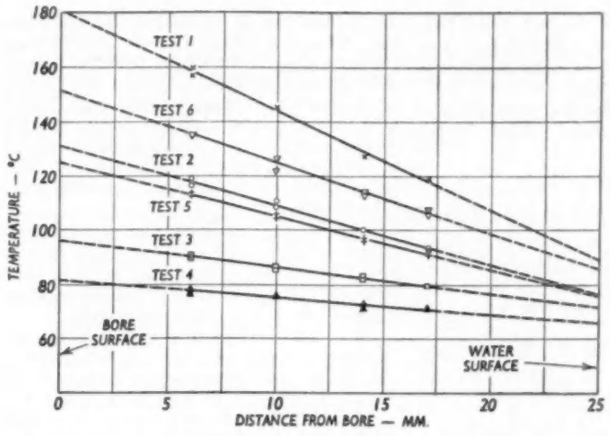
Note : Tests 1 to 4 lie on a propeller curve. Tests 2, 5 and 6 have approximately constant fuel flow.

TABLE V—*Doxford Single-Cylinder Engine, 670mm×(1340+980)mm. Summary of Liner-Temperature and Local Heat-Flow Tests*

Test No.	Symbol	Extrapolated temperature at inner face, deg. Cent.											
		7E	6E	5E Fixed	4E	3E	2E	1	2S	3S	4S	5S Fixed	6S Fixed
1	×	72·3	75·1	73·0	79·6	99·8	131·0	181·0	131·0	78·5	67·2	67·0	64·0
2	○	66·4	68·0	66·0	70·2	86·0	101·0	130·5	95·0	70·3	65·5	65·0	64·0
3	⊡	65·7	67·1	69·5	72·8	92·0	88·0	96·0	86·0	68·5	64·2	63·5	63·5
4	△	65·0	63·5	63·5	66·7	70·0	74·6	81·2	75·0	66·0	64·0	62·5	61·0
5	+	66·5	67·3	67·0	70·0	87·1	97·8	124·8	98·0	71·9	66·0	67·0	64·5
6	▽	70·0	71·6	70·5	76·3	89·3	122·1	151·0	113·0	75·5	67·9	70·0	66·5

Test No.	Symbol	Extrapolated temperature at outer face, deg. Cent.								
		7E	6E	4E	3E	2E	1	2S	3S	4S
1	×	90·3	66·8	64·0	77·4	86·2	89·0	68·0	61·0	57·2
2	○	80·0	62·9	62·0	69·9	78·6	76·0	64·0	61·7	60·6
3	⊡	71·0	64·8	67·2	71·8	72·4	71·5	65·5	62·0	61·5
4	△	66·5	62·0	64·8	65·0	66·2	66·0	63·5	64·0	62·8
5	+	74·4	63·6	64·0	70·1	75·7	75·2	66·5	64·4	60·0
6	▽	84·7	66·1	68·0	73·4	86·0	85·3	74·5	64·1	59·6

Test No.	Symbol	Temperature gradient, deg. Cent. per centimetre							
		6E	4E	3E	2E	1	2S	3S	4S
1	×	3·32	6·24	8·96	17·9	36·8	25·2	7·0	3·3
2	○	2·04	3·28	6·44	8·96	21·8	12·4	3·44	1·63
3	⊡	0·92	2·24	8·08	6·24	9·8	8·2	2·6	0·9
4	△	0·6	0·76	2·0	3·36	6·08	4·6	0·8	0·4
5	+	1·48	2·4	6·8	8·85	19·9	12·6	3·0	2·0
6	▽	2·2	3·4	6·37	14·45	26·3	15·4	4·57	2·77



See Table IV for engine test conditions.

Fig. 3—Temperature gradients at position 1. Doxford single-cylinder engine

and details are given in Table III. It was not possible to traverse No. 5E because of external obstructions, while Nos. 5S and 6S lay within the scavenge belt and could be moved only when the engine was stationary. As the temperature gradient at this level was very low, it was decided to use these two thermocouples as fixed couples only.

No. 7E couple was sited in one of the exhaust-port bars. It was initially intended that it should have been towards the lower or inner centre end, which receives the brunt of the heating from the initial outflow of exhaust, but obstructions prevented this and it was inserted towards the upper end.

Test Technique

It was found that a "settling-down" period of about one hour was required to ensure steady temperatures; this was in addition to the normal warming-up period.

The couples were traversed in turn and readings of temperature were taken at four positions on the outward traverse and again on the inward traverse. The temperature gradients were obtained by drawing mean lines through plots of these two sets of readings.

The calibration of the chromel-alumel couples was taken from B.S. 1827 : 1952. One couple was checked on the site at 63 deg. Cent. and found to be correct.

Sets of temperature readings were made at six engine conditions. Four of these lay on a propeller curve from full load to minimum load; three were made at various speeds and torques, but at an approximately constant gross rate of fuel consumption. The engine-test conditions are listed in Table IV and are the mean values of about three readings taken during each test.

There was no provision for measuring the rate of coolant flow through the liner water jacket, but Doxfords stated that it was about 6000–6500 gallons per hour. The temperature of the water into and out of the jacket was measured, but the thermometers were rather remote from the cylinder, as there was about 45ft of 2¼in o.d. copper pipe between thermometers and engine. In these circumstances estimation of the gross heat losses could only be very approximate. Doxfords stated that in earlier tests the jacket loss amounted to 10·7 per cent of the fuel heat.

Liner-Temperature and Heat-Flow Results

Fig. 3 shows by way of example, the plots of the temperatures observed at Position No. 1 for the six engine conditions, while Table V lists the inner and outer surface temperatures of the liner at all stations, together with the temperature gradient, under each test condition. Fig. 4 is a plot of the temperatures at the inner and outer surface of the liner at full load, and Fig. 5 shows the temperature gradients at this condition.

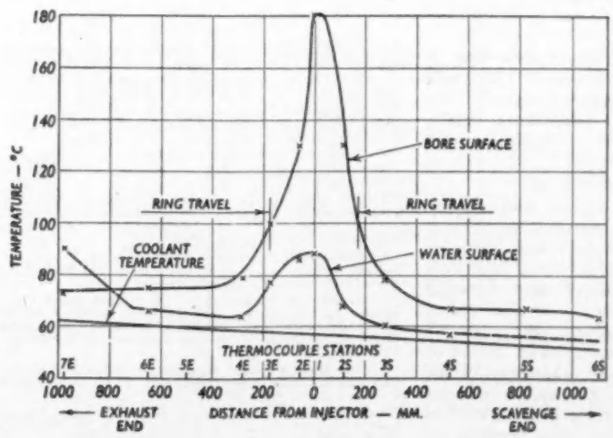


Fig. 4—Liner temperatures at full load. Doxford single-cylinder engine

Discussion of Results

Bore-Surface Temperature.—The highest bore-surface temperature observed was 180 deg. Cent. (356 deg. Fah.) at Station No. 1 on the centre line of the combustion chamber when running at full load, but the temperature diminishes rapidly above or below this station, and, in fact, even at full load there is a band only 200mm wide which experiences a temperature of 120 deg. Cent. (248 deg. Fah.) or more. The path of the piston-ring travel is entirely outside this zone. Fig. 6 shows the bore-surface temperature at the inner end of travel of the first ring over the range of load tested. The values shown refer equally to the exhaust or scavenge pistons as there was remarkably close similarity between these two positions The lower curve in this figure shows the temperature at station 6S, which is towards the outer travel of the scavenge piston. It will be seen that the highest temperature reached in line with the ring travel is 100 deg. Cent. (212 deg. Fah.) falling to about 60 deg. Cent. (140 deg. Fah.) at the outer limit of travel at light load.

This level of temperature is lower than had been expected and is in the range where condensation of products of combustion

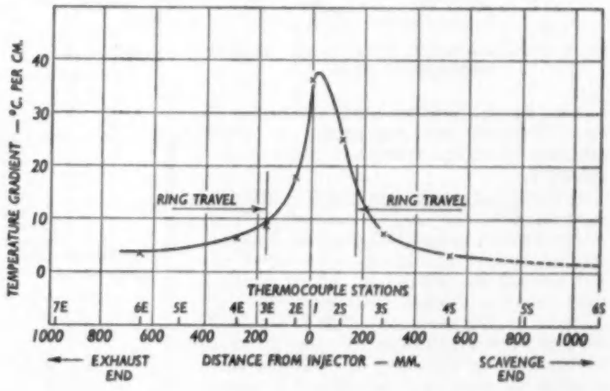


Fig. 5—Temperature gradients in liner at full load. Doxford single-cylinder engine

may occur. However, the precise value of temperature at which condensation will start and the general mechanism of condensation are debatable matters, and have been the subject of discussion in the literature for some time.

The water formed in the combustion process will result in a dew point of about 40 deg. Cent. (104 deg. Fah.) but this is with the gases at atmospheric pressure. Early in the expansion stroke the water dew point would be as high as 130 deg. Cent. (266 deg. Fah.) when the cylinder pressure is at several hundred pounds per square inch. It is likely therefore that some water condensation occurs on the cylinder surfaces early in the expansion stroke, only to be re-evaporated later in the stroke. This process does not appear to be harmful judging by experience on gasoline engines, provided that the cylinders are maintained at a temperature of at least 50 deg. Cent. (122 deg. Fah.). However, this picture is altered when considering an engine burning a fuel containing sulphur. The greater part of the sulphur burns to sulphur dioxide, which passes out of the engine in gaseous form, but a proportion of the sulphur burns to sulphur trioxide which, in the presence of water vapour, may condense to form sulphuric acid. Even if only, say, 5 per cent of the total sulphur burns to sulphur trioxide,

then the acid dew point would be about 140 deg. Cent. (284 deg. Fah.) at atmospheric pressure rising to perhaps 200 deg. Cent. earlier in the expansion stroke of the engine. As the cylinder walls are at a lower temperature than these dew-point values there will be a tendency for condensation of sulphuric acid to take place on the walls.

A series of publications[3, 4, 5] by members of the staff of the British Coal Utilisation Research Association have demonstrated these processes under conditions of continuous combustion, but other authorities[6, 7] have disputed the importance or even existence of sulphur trioxide in diesel engine cylinders.

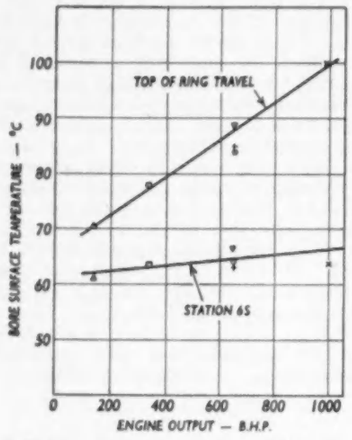


Fig. 6—Bore temperatures at ring travel. Doxford single-cylinder engine

A complication is that sulphur trioxide may be adsorbed on to carbon particles always present in diesel combustion, in which case a normal dew point may not be observed, but nevertheless Flint and others[5] showed that corrosion would still occur on cool surfaces in the same way that it would if carbon were not present. Precise practical information on the effect of operating temperature on wear in diesel engines is scarce, but the present author[8] gave figures indicating that wear increased rapidly when the temperature of the cylinder-bore surface, as measured at the top of the ring travel, fell below 120 deg. Cent. (248 deg. Fah.).

It is evident that there is every likelihood that condensation of sulphuric acid will take place in the Doxford engine and consequently it is probable that corrosion contributes to the wear processes.

Temperature Gradients and Heat Flux

A plot of the temperature gradient through the liner thickness at full load is shown in Fig. 5. The maximum gradient is in the zone of the combustion chamber and at full load rises to 37 deg. Cent. per centimetre, but the gradient falls rapidly at positions away from the centre line of the chamber and the gradient is less than half this peak value at the level of the ring travel.

It will be noticed that there are appreciable gradients along the liner in an axial direction amounting to about 10 deg. Cent. per centimetre in the combustion-chamber zone at full load.

The radial temperature gradients will give rise to hoop stresses in the liner. It is estimated that there will be a compression hoop stress of 6·4 tons per square inch on the inner surface of the liner in the combustion chamber zone owing to the temperature gradient of 37 deg. Cent. per centimetre and a tensile load of 6·2 tons per square inch on the outer surface. This estimation is based on a simple cylinder 25mm thick and of 670mm bore; it does not take into account the detailed constructional design of the Doxford liner with its reinforcing bands. The gas loading on such a simple cylinder would amount to 4 tons per square inch at 650 lb per square inch gas pressure.

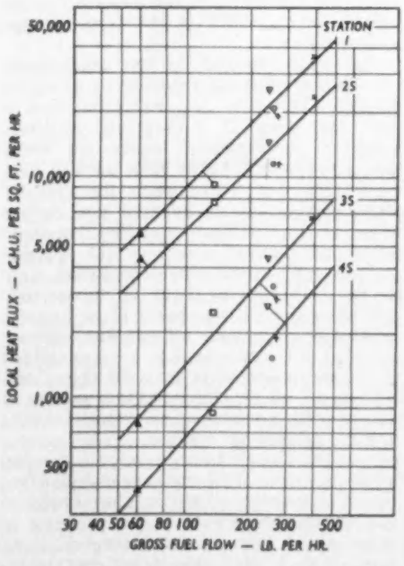


Fig. 7—Heat flux in liner, scavenge end. Doxford single-cylinder engine

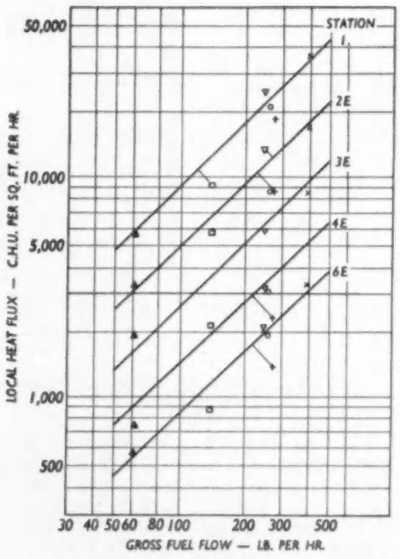


Fig. 8—Heat flux in liner, exhaust end. Doxford single-cylinder engine

A recent paper by Alcock and others[9] discussed in detail the distribution of heat flow in diesel engines and data were given for values of heat flux or local rate of heat flow showing correlation between heat flux and gross fuel consumption. Similar plots of heat flux are given in Figs. 7 and 8 for the present tests. The values of heat flux at the top of the ring travel of the order of 20,000 C.H.U. per square foot per hour shown are of the same general level as reported by Alcock for the engines he investigated, which were of 5in and 7½in bore. The values recorded in the combustion chamber zone of 40,000 are, however, somewhat lower than those reported by Alcock, which ranged between 50,000 and 70,000 C.H.U. per square foot per hour, but the presence of valves in the cylinder-heads of his engines appeared to concentrate the heat flux between the valves, giving rise to these higher values.

Towards the outer ends of the Doxford liner very low flux levels exist; this is probably due to a combination of the long stroke of the engine and the low temperature of the skirts of the oil-cooled pistons.

On the Doxford engine heat flux appears to increase nearly directly proportionally to the gross fuel consumption, whereas on smaller engines the heat flux has been found to rise a little less rapidly than this, an average relationship being heat flux proportional to gross fuel consumption raised to the 0·75 power. The reason for this is not clear. If a unique relationship between fuel rate and heat flux be assumed, then it follows that up-rating the engine will give rise to increased thermal loading even though the fuel-air ratio and exhaust temperature be held constant by increased supercharging. The present tests do not prove this point, but Alcock's results suggest it to be approximately so, although there was a trend to a somewhat lower heat flow than expected at high supercharge on one diesel engine.

Conclusions

A survey of the temperature of a Doxford cylinder liner has shown that the cylinder bore surface is running at a relatively low level of temperature and as a result condensation of cylinder acids may very well occur. There is, therefore, a likelihood that corrosion will play a part in the mechanism of wear in these engines.

The recorded temperature gradients give an indication of the thermal stresses encountered in this engine, which appear to be moderate.

The local rates of heat flow deduced from the temperature survey add useful information to the limited data on this subject. The order of magnitude of heat flux is in agreement with more detailed information available on smaller engines.

Acknowledgments

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References

[1] "The Doxford Engine: Progress and Development," Storey, A., *Trans. N.E. Cst. Inst. Engrs. Shipb.*, 72 (1956), page 327.

[2] "Heat Flow Measurements," Ricardo and Co., Aeronautical Research Council, R. and M. 2171, November, 1946.

[3] "A Method for the Determination of Small Concentrations of SO_3 in the Presence of Larger Concentrations of SO_2," Flint, D., *Journal Soc. Chem. Ind.*, London, 67 (1948), page 2.

[4] "An Investigation of Dew Point and Related Condensation Phenomena in Flue Gases," Flint, D., *Journal Inst. Fuel*, 21 (1948), page 248.

[5] "The Effect of Carbon Smoke on Corrosion and Dew Point Phenomena in Gases Containing Sulphur Trioxide," Flint, D., Kean, R. W., and Whittingham, G., "B.C.U.R.A. Information Circular," No. 33, 1950.

[6] "SO_3 and SO_2 in Exhaust Gases of Internal Combustion Engines," Zijden, M. J., van der Hinte, J. E., and Ende, J. S., *Journal Inst. Petrol*, 36 (1950), page 561.

[7] "Combustion Products and Wear in High Speed Compression Ignition Engines, with Particular Reference to the Use of Low Grade Fuels," Lyn, W. T., *Institution of Mechanical Engineers, Proceedings of the Joint Conference on Combustion*, 1955, page 242.

[8] "Life Tests on a Small High Duty Engine with Particular Reference to Chrome Bores," Millington, B. W., Diesel Engine Users Association, May, 1955.

[9] "Distribution of Heat Flow in High-Duty Internal Combustion Engines," Alcock, J. F., Robson, J. V. B., and Mash, C., Zurich International Congress on Combustion, 1957.

Experiments on a Piston Controlled Port

By R. S. BENSON, M.Sc.(Eng.), Ph.D., A.M.I.Mech.E.*

This article describes steady flow experiments on a single piston controlled rectangular port. The experiments were carried out over a range of pressures from 0 lb to 100 lb per square inch gauge and temperatures 70 deg. to 550 deg. Fah. Various methods for correlating the coefficient of discharge for compressible flow with the coefficient of discharge for incompressible flow are discussed and the test results compared with the Buckingham-Jobson formulæ. This gave good agreement for subsonic flow in the jet, but there was some discrepancy at high pressures with sonic flow. The elevated temperature experiments showed that the influence of air temperature on the coefficient of discharge was not significant above a certain Reynolds number; for all the experiments the variation in coefficient of discharge for a constant pressure did not exceed 3 per cent.

COMPREHENSIVE theoretical and experimental studies have been made of flow through sharp-edged circular orifices and methods have been developed for calculating the mass flow through orifices from the pressure measurements before and after the orifice. The wealth of information obtained from these investigations enables flow calculations to be made with a high degree of accuracy without the necessity of preliminary investigations of the flow characteristics of orifice systems. In particular, the variation of the coefficient of discharge with Reynolds number, Mach number and overall pressure ratio can be determined for a given orifice providing the pipe system conforms to the appropriate standard. It is usual in these methods[1] to assign the coefficient of discharge to the value for incompressible flow through the orifice and to allow for the expansion of the jet in compressible flow cases by a suitable compressibility coefficient; if, however, the coefficient of discharge is defined as the ratio of the actual mass flow to the theoretical mass flow assuming the flow to run full through the orifice and the expansion is isentropic it will be found that there is a relationship between the coefficient of discharge for incompressible flow and the coefficient of discharge for compressible flow. For these configurations therefore experimental determination of the coefficient of discharge at low pressure ratios across the orifice provide sufficient data for the determination of the coefficient of discharge at high pressure ratios. This is of great practical importance since experiments may be carried out more readily at low pressure ratios than at high pressure ratios since the compressor or blower plant will then be within the requirements of the average laboratory or test plant.

The rectangular port with a piston controlling the port opening is frequently used in engineering problems. A knowledge of the effective port area is necessary for flow calculations. Since it is probably difficult to obtain experimentally the coefficient of discharge for such systems at high pressure ratios it would appear that a similar correlation might be made between the coefficient of discharge at low pressure ratios and at high pressure ratios for rectangular ports as that made for circular sharp edged orifices. In this article the results are given of an experimental investigation of flow through a single rectangular port to establish whether such a correlation may be made. A number of theoretical and empirical methods were investigated, the test results were finally correlated by the methods suggested by Buckingham[2] and Jobson.[3]

It has been suggested by Wallace and

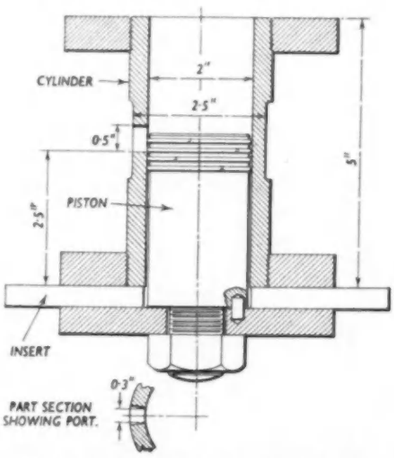

Fig. 1—Cylinder and piston for single port tests

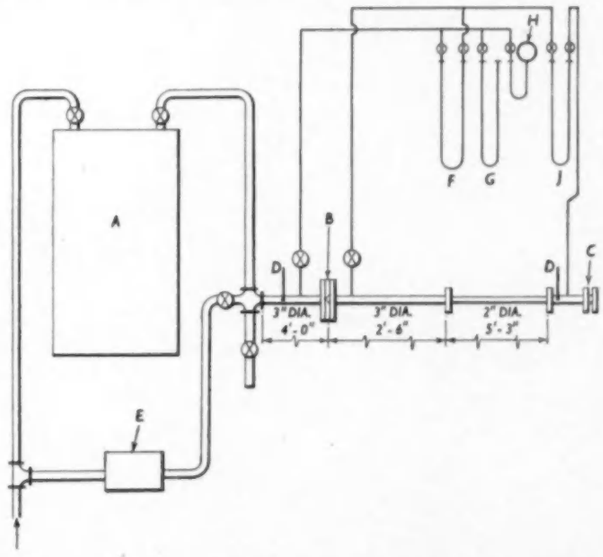

Fig. 2 — Pipe layout for single port tests

* The University of Liverpool.

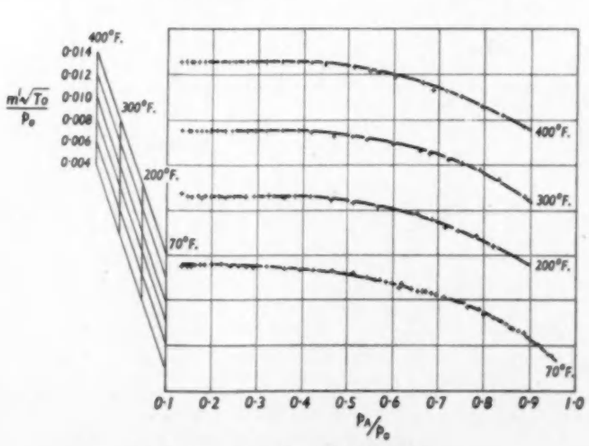

Fig. 3—Test results, port height 0·1in

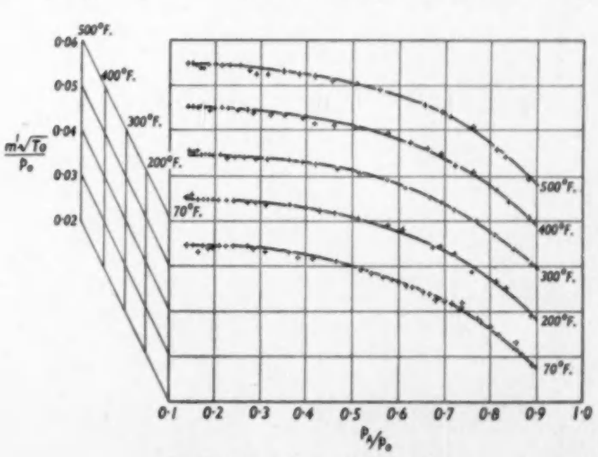

Fig. 4—Test results, port height 0·4in

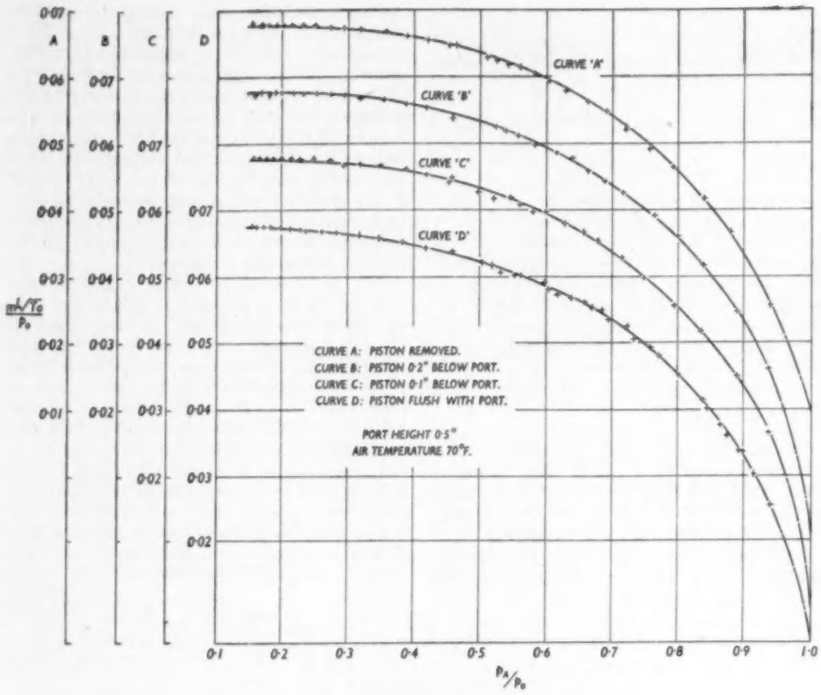

Fig. 5—Test results for various port heights

Mitchell[4] that the coefficient of discharge for an exhaust port of a two-stroke cycle engine was influenced to a great extent by the gas temperature. Experiments were therefore carried out at elevated temperatures to establish whether these effects were noticeable in a single port. For this purpose the air was heated up to 550 deg. Fah. and the results correlated on a Reynolds number basis.

Apparatus

Fig. 1 shows a cross section of the cylinder, piston and port arrangement. A single rectangular port 0·3in wide × 0·5in high was machined into a phosphor bronze cylinder 2in bore. The sides of the port were radial with the cylinder centre and the upper and lower edges were perpendicular to the cylinder axis. A solid phosphor bronze piston with cast iron piston rings was inserted into the piston to control the port opening. The piston was machined to give a push fit and the upper piston ring was located as near to the flat crown as possible, by this means leakage was eliminated. The port opening was adjusted by fitting inserts between the flanges as shown.

The whole assembly was mounted downstream of a measuring orifice to conform to B.S.S. 1042 : 1943. The layout is shown in Fig. 2. A small gas heater was used for the low temperature experiments to ensure a dry air supply. For the elevated temperatures a gas-fired superheater was used ; this gave a maximum temperature at the ports of the order of 550 deg. Fah. The whole system except the cylinder was lagged. The air mass flow was measured with sharp edged orifices with D and $D/2$ taps according to B.S.S. 1042 : 1943.

Experimental Results

The experimental results were plotted in the form of a mass flow group $m^1\sqrt{T_0}/p_0$ where

m^1 = mass flow pounds per second

T_0 = stagnation temperature, deg. R

p_0 = stagnation pressure, pound per square inch absolute.

Typical test results are shown in Figs. 3 to 5 where the mass flow group is plotted against the pressure ratio p_A/p_0 (p_A = atmospheric pressure).

In Fig. 3 the results are given for the port height 0·1in for nominal air temperatures 70 deg., 200 deg., 300 deg. and 400 deg. Fah. Fig. 4 shows similar results for the port height 0·4in with an additional curve for an air temperature of 500 deg. Fah. The results shown in Fig. 5 correspond to the full port opening 0·3in × 0·5in with the air temperature 70 deg. Fah. The curves correspond to the piston flush with the bottom of the port, the piston 0·1in and 0·2in below the port and the piston removed.

The coefficient of discharge C was calculated by dividing the actual mass flow m^1 by the theoretical mass flow m defined as the mass flow through the port assuming the flow to run full with isentropic expansion. Figs. 6 (*a*) to 6 (*e*) show the coefficient of discharge for all the tests. Based on these curves the variation of the coefficient of discharge with piston position is shown in Fig. 6 (*f*).

Although the air temperature was maintained constant at the superheater there was some temperature drop to the port. This was more marked at low pressures. In Figs. 7 and 8 the variation of the coefficient of discharge with the temperature at the port is plotted for port heights 0·1in and 0·4in respectively. These results are replotted against the Reynolds number at the orifice in Figs. 9 and 10. For this purpose the air temperature in the port was calculated assuming isentropic expansion from stagnation conditions.

Correlation Between Compressible and Incompressible Coefficients of Discharge

Before analysing the experimental results a survey was made of the methods used for correlating the compressible coefficients of discharge. Due to the complex three-dimensional geometric form of the cylinder, piston and port arrangement it is difficult to develop an analytical method correlating the compressible coefficient of discharge C with the incompressible coefficient of discharge C_i. An empirical method must therefore be considered. A number of such methods have been developed for sharp edged circular orifices and certain of these give close agreement with the experimental results. Two distinct approaches can be noted in these methods; in the first, the results obtained by a mathematical analysis of flow through a two-dimensional slit have been applied to

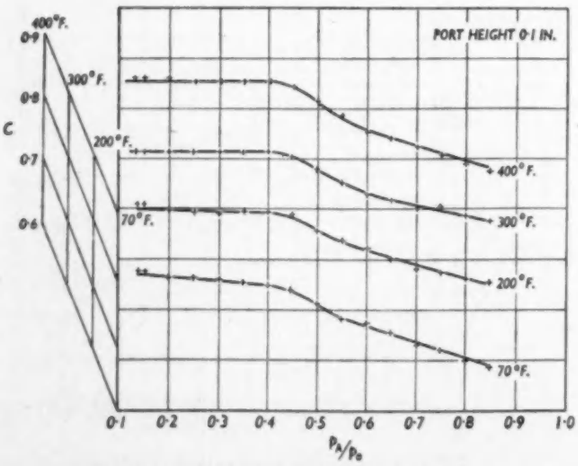

Fig. 6 (*a*)—Coefficient of discharge, port height 0·1in

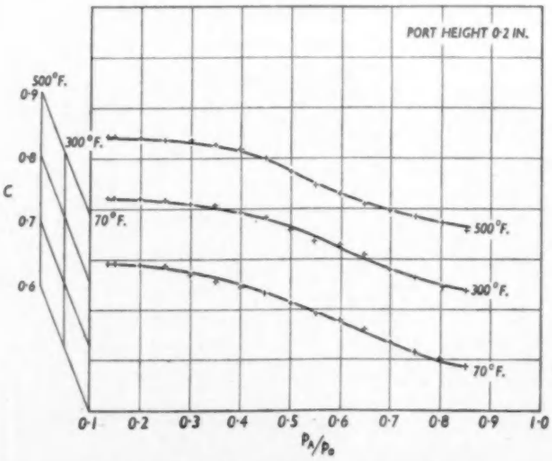

Fig. 6 (*b*)—Coefficient of discharge, port height 0·2in

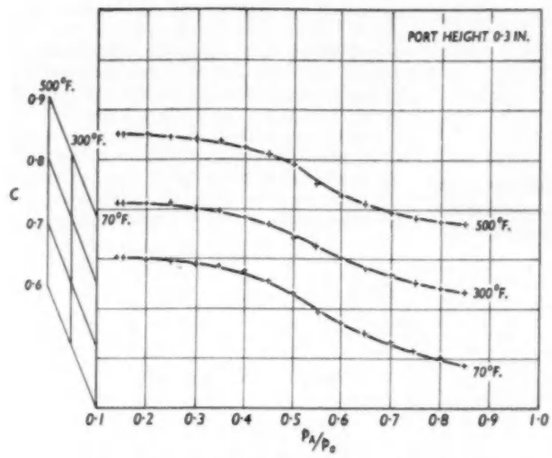

Fig. 6 (c)—Coefficient of discharge, port height 0·3in

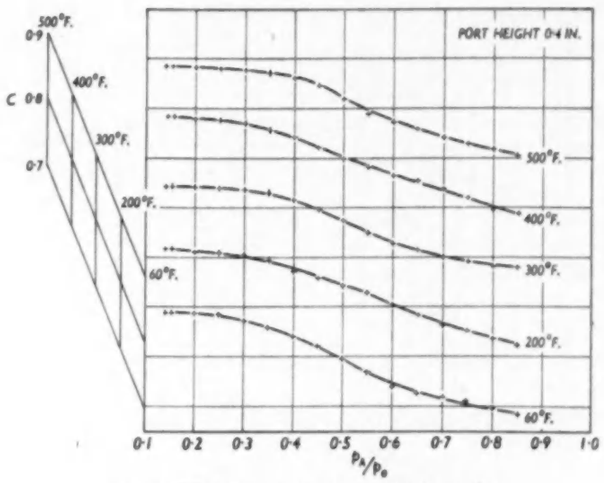

Fig. 6 (d)—Coefficient of discharge, port height 0·4in

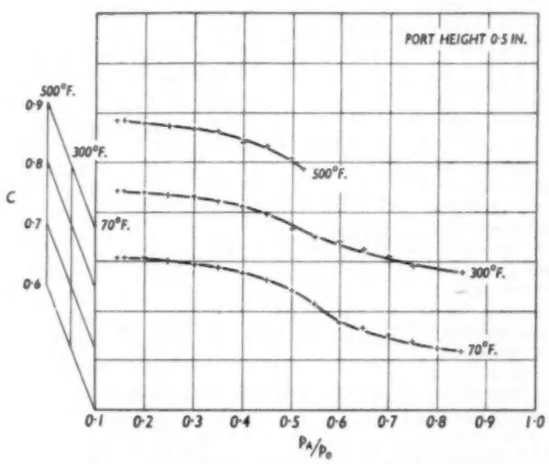

Fig. 6 (e)—Coefficient of discharge, port height 0·5in

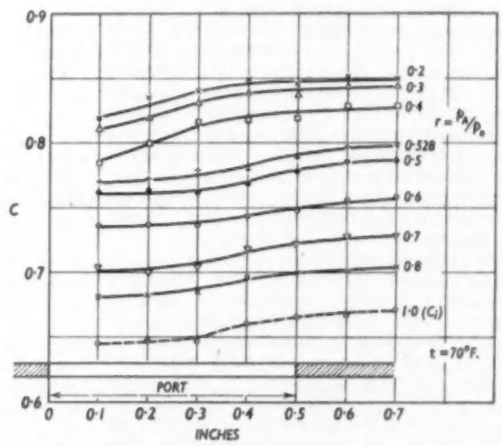

Fig. 6 (f)—Variation of coefficient of discharge with piston position

orifice calculations. In the second method assumptions are made as to the pressure distribution in the plane of the orifice and at the *vena contracta*, and the expansion of the jet is calculated by the normal Bernoulli equation either directly (i.e. the energy theorem) or by a combination of the energy equation and the momentum equation.

The two-dimensional slit can be analysed by a mathematical solution of the two-dimensional equations of motion. An exact solution can be obtained for the ratio of the jet width at the *vena contracta* to the width of the slit from low pressures up to sonic flow in the jet. This exact solution is due to Chaplygin;[5] results of recent calculations[6] based on Chaplygin's solution are given in Fig. 11 (curve 1). The mathematical form of this solution is complex and attempts have been made to develop approximate methods notably by Busemann.[7,8] The Busemann solutions are based on the tangent gas approximation. The first,[7] based on Demtchenko's tangent gas approximation, gave the coefficient of discharge C as

$$C=\frac{\pi}{\pi+2\left(1-\frac{1}{\gamma}(1-p_A/p_0)\right)} \quad . \quad . \quad (1)$$

where p_0 and p_A are the stagnation and downstream pressures respectively. Calculations based on this equation are given in Fig. 11 (curve 5). Later Busemann[8] used the hodograph transformation and the tangent gas approximation and obtained the following equation for the two-dimensional slit

$$C=\frac{\pi}{\pi+2(\rho_2/\rho_0)} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where ρ_0 is the stagnation density and ρ_2 the density of the gas in the jet at the *vena contracta*. For incompressible flow $\rho_2=\rho_0$ and $C=C_i=0{\cdot}611$.

The density ratio ρ_2/ρ_0 by the tangent gas approximation is $(1-M_2^2)^{\frac{1}{2}}$ where M_2 is the Mach number of the throat. The variation of C with p_A/p_0 for this case is given in Fig. 11 (curve 2). Although this expression gives good agreement for low gas speeds the errors increase as the overall pressure ratio is increased. To obtain closer agreement Shapiro[9] has suggested using the isentropic expression $\rho_2/\rho_0=(p_A/p_0)^{1/\gamma}$; the results of this approximation are shown in curve 3. This approximation only extends the accuracy a slight amount although it gives close results for high overall pressure ratios. Since the change in temperature is only some 20 per cent up to sonic flow in the port we may assume isothermal expansion across the slit, the results for this assumption are shown in Fig. 11, curve 4. This approximation gives

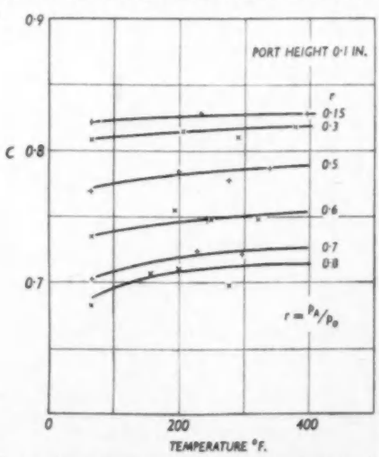

Fig. 7—Variation of coefficient of discharge with temperature, port height 0·1in

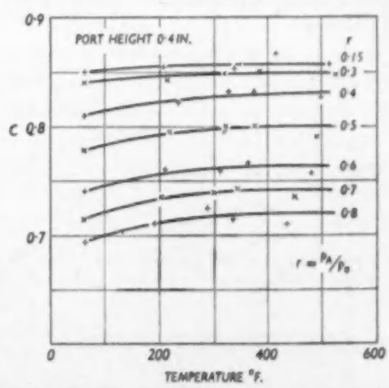

Fig. 8—Variation of coefficient of discharge with temperature, port height 0·4in

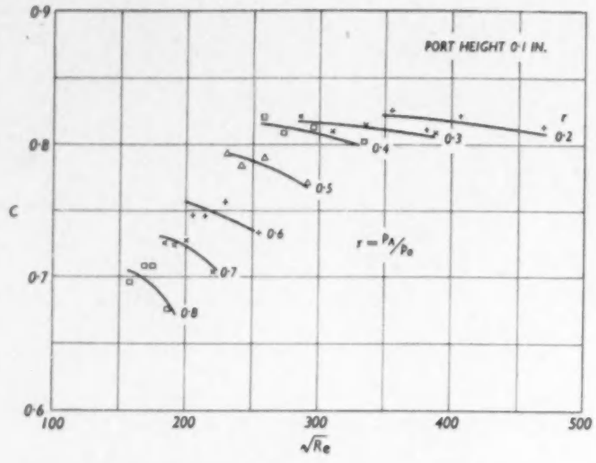

Fig. 9—Coefficient of discharge v. Reynolds number, port height 0·1in

better results at the high pressures but loses accuracy in the middle of the subsonic range.

Although specifically all the above methods have been based on the two-dimensional slit they have been applied to correlating circular orifice results. It was shown by Southwell[10] that for incompressible flow there is very little difference between the discharge coefficient for an axisymmetric sharp edged orifice and a two-dimensional slit (C_i 0·608 and 0·611 respectively); hence, within reason the two-dimensional slit may give one method for correlating the compressible and incompressible coefficients of discharge.

Alternative approaches not based on the mathematical solutions of the differential equations of motion have been developed by Witte,[11, 12] Ruppel,[13] Nusselt,[14] Buckingham[2] and Jobson.[3] These methods give expressions of varying complexity and are generally in a form that can be applied to any orifice system. The basis of all the methods is to give an expression for calculating the coefficient of discharge for compressible flow from the incompressible value. Witte,[11, 12] and Ruppel[13] considered that the jet expanded uniformly in all directions downstream of the orifice. By a series of assumptions equations are developed connecting the pressures upstream of the orifice, in the plane of the orifice and at the *vena contracta*. In the simplest form assuming isothermal flow from the stagnation pressure to the pressure at the *vena contracta* the following expression was obtained

$$C=C_i\{(p_0/p_A)[1-C_i^2(1-(p_A/p_0))]\}^{2/3\gamma} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Witte[11] suggested that this expression should be used as a first approximation; by substituting the first approximation in the C_i^2 term a closer approximation would be obtained thus:—

$$C=C_i\{(p_0/p_A)[1-C_e^2(1-(p_A/p_0))]\}^{2/3\gamma} \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

where C_e is the first approximation and is given by

$$C_e=C_i\{(p_0/p_A)[1-C_i^2(1-(p_A/p_0))]\}^{2/3\gamma} \quad . \quad . \quad . \quad . \quad . \quad (4b)$$

At a later date Witte[12] modified his expression to allow for isentropic expansion from stagnation pressure to the pressure at the *vena contracta;* in their new form the equations were more complex. In Fig. 12 three curves are given based on Witte expressions for C_i=0·611, curve 2 corresponds to equation (3), curve 3 to equations (4*a*) and (4*b*), and curve 4 to the modified equations assuming isentropic expansion from stagnation conditions. Of all the three methods the original simple expression (equation 3) gives closest agreement with the exact solution.

By considering the flow under compressible and incompressible conditions to be similar in an orifice and in a Borda tube, and by allowing by an empirical method for the curvature of the streamlines in the plane of the orifice Nusselt[14] developed a method for calculating the expansion of the jet at the *vena contracta*. The formulæ were somewhat complex. In Fig. 11, curve 6, the results are given for C_i=0·611.

A simpler approach using the momentum equations was developed first by Buckingham[2] and later by Jobson.[3] It was assumed in both cases that the pressure distribution in the plane of the orifice was the same for compressible and incompressible flow. Buckingham[2] arranged his equations so that the unknown pressure distribution could be eliminated from the momentum equations for compressible and incompressible flow. Jobson[3] assumed that the difference in pressure some distance upstream of the orifice and the pressure on the wall, called the force defect, was a function of the mass flow, the area of the orifice and the stagnation density. By dimensionless analysis and substitution in the incompressible flow equations he showed that the force defect was a function of the incompressible coefficient of discharge. By assuming the force defect was unchanged for compressible flow the following expressions were obtained (in both cases),

$$C=Ar^{-1/\gamma}[1-(1-(B/A))^{\frac{1}{2}}] \quad . \quad . \quad . \quad (5)$$

where

$$A=\frac{C_i^2}{2C_i-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$B=r^{2/\gamma}(1-r)\left(\frac{\gamma-1}{\gamma}\right)D^{-2} \quad . \quad . \quad . \quad . \quad (7)$$

$$D^2=(r^{2/\gamma}-r^{(\gamma+1)/\gamma}) \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

$r=p_A/p_0$.

This method gives good agreement with the exact solution for a two-dimensional slit as will be seen in curve 5, Fig. 12.

Both the Nusselt and Buckingham-Jobson formulæ can be extended into the sonic

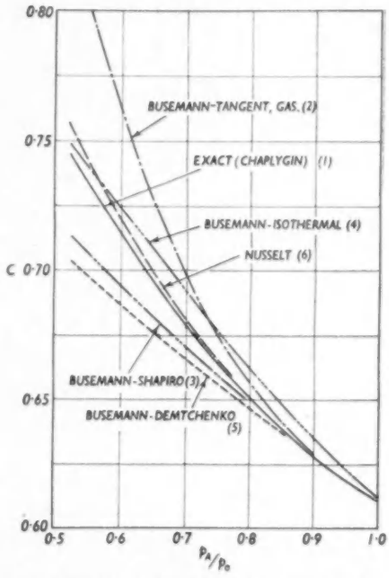

Fig. 11—Coefficient of contraction of area of two-dimensional slit

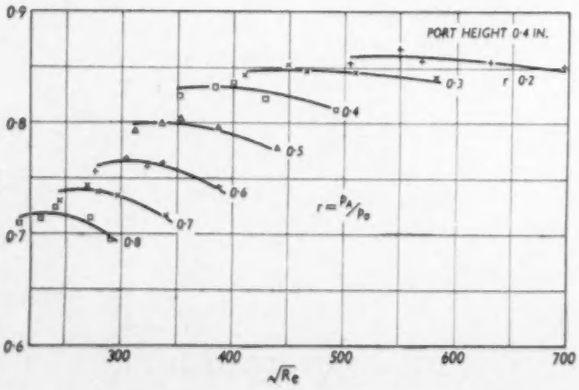

Fig. 10—Coefficient of discharge v. Reynolds number, port height 0·1in

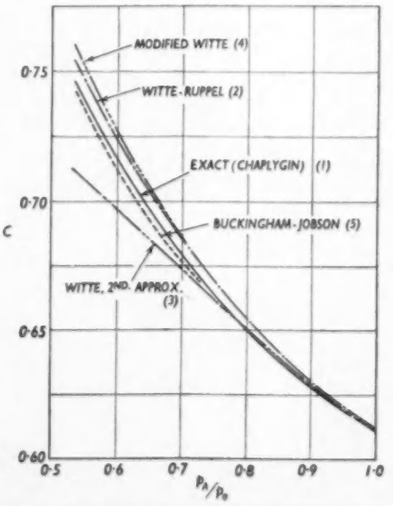

Fig. 12—Coefficient of contraction of area of slit

region. However, as will be seen in Fig. 13, there is a marked divergence in the results for this case. Nusselt did not allow for the critical pressure conditions in the throat and the value of C could exceed unity. Jobson considered that the pressure distribution on the wall of the orifice plate to be the same for

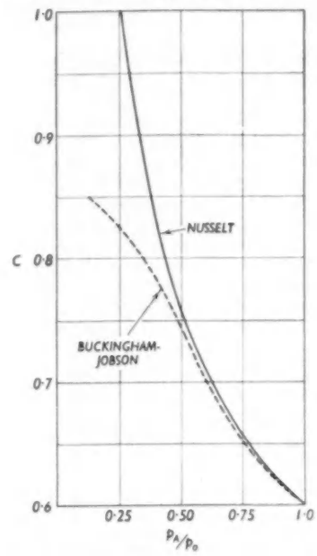

Fig. 13—Coefficient of discharge for subcritical and supercritical flow

subsonic and sonic flow, he further assumed that the sonic line was normal to the jet. Although these assumptions are not strictly true they enable the formulæ to be extended into the sonic range. For this case where $r=p_0/p_A$ we have

$$C=\beta A(1-(1-(\lambda/A))^{\frac{1}{2}}) \quad . \quad . \quad . \quad (9)$$

$$A=\frac{C_t^2}{2C_t-1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

$$B=(p_t/p_0)(1+\gamma) \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$D=\gamma(\gamma+1)(p_t/p_0)^2 \quad . \quad . \quad . \quad . \quad (12)$$

$$\beta=\frac{2(B-r)}{D} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

$$\lambda=\frac{D(1-r)}{(B-r)^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$\frac{p_t}{p_0}=\text{critical pressure ratio}=\left(\frac{2}{\gamma+1}\right)^{\gamma/(\gamma-1)} \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Both Buckingham and Jobson have indicated that their expressions give good agreement with experimental results providing C_t is less than 0·7. This limitation is associated with

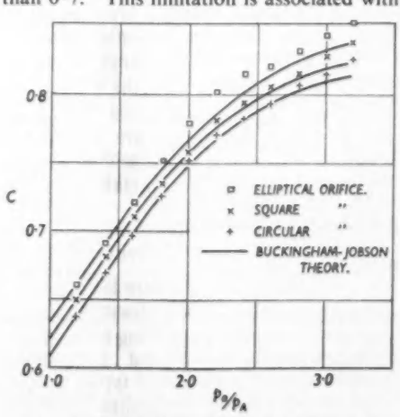

Fig. 14—Comparison of N.A.C.A. test with Buckingham-Jobson theory

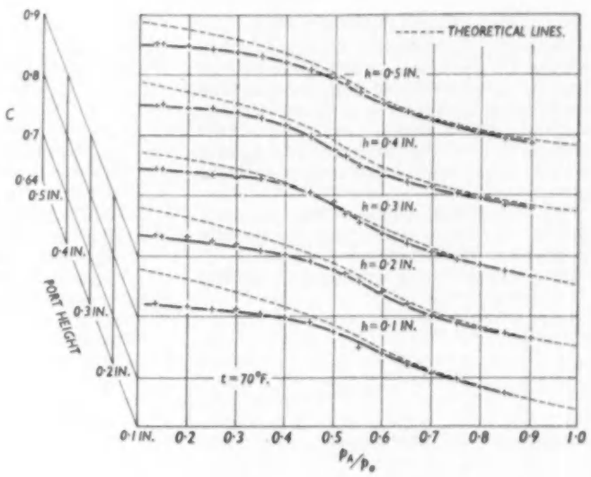

Fig. 15—Coefficient of discharge for all port openings

the flow upstream of the orifice. For high values of C_t it is considered that compressibility effects become more significant upstream of the orifice as the overall pressure ratio is increased. Thus the force defect will not remain constant. In Fig. 14 results are given of a correlation made by the author of some recent N.A.C.A. tests by Callaghan and Bowden[15] on sharp edged circular, square and elliptical orifices. It will be seen that there is good agreement between the experimental results and the theoretical curves based on the Buckingham-Jobson theory.

In view of the good agreement obtained with the Buckingham-Jobson theory noted above, the experimental results obtained with the single rectangular port were compared with the theoretical predictions by this theory. In Figs. 15 and 16 the results of this correlation are given. It will be seen that for subsonic flow there was close agreement between the calculated values of C and the observed values. For sonic flow the calculated values exceed the experimental values, the error increasing as the overall pressure ratio increases. The magnitude of the error was dependent on the port position but in no cases exceeded 6 per cent (at $p_A/p_0=0·2$) and in many cases was as low as 2 per cent (at $p_A/p_0=0·2$).

These experiments indicate that a preliminary basis is available for correlating the coefficient of discharge for compressible flow and incompressible flow but further analysis is necessary to obtain increased accuracy in the sonic region.

Influence of Temperature on Coefficient of Discharge

Since the coefficient of discharge is a function of the overall pressure ratio the comparison of the results at different air temperatures must be for fixed pressure ratios. The results given in Figs. 9 and 10 showed that over the range of temperatures examined the effect of temperature is not significant. As would be expected, the influence of temperature is more marked at low pressures where the mass velocity is low and hence the Reynolds number is low.

In the analysis of results of these experiments the specific heats were assumed to be constant. At elevated temperatures the specific heats will increase and the numerical value of γ decrease. Jobson[3] has shown that equations (5) and (9) may be used for both air ($\gamma=1·4$) and steam ($\gamma=1·3$). Using these equations the effect of γ on the coefficient of discharge can be calculated ; the results are shown in Fig. 17. The effect of γ is more noticeable at high overall pressure ratios.

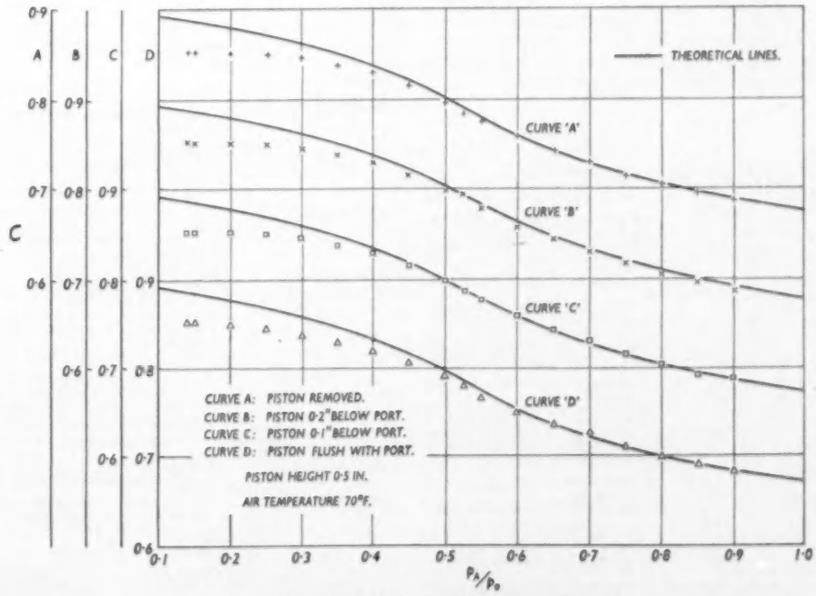

Fig. 16—Coefficient of discharge for port opening 0·5in

Conclusions

The experiments showed that for a single rectangular port the Buckingham-Jobson formulæ correlating the compressible flow coefficients of discharge and the incompressible flow coefficients gave good agreement for subsonic flow but there was some discrepancy at high-pressure ratios with sonic flow in the jet.

The experiments showed that the same factors influence the coefficient of discharge at elevated temperatures in ports as in orifices. That is for a low Reynolds number

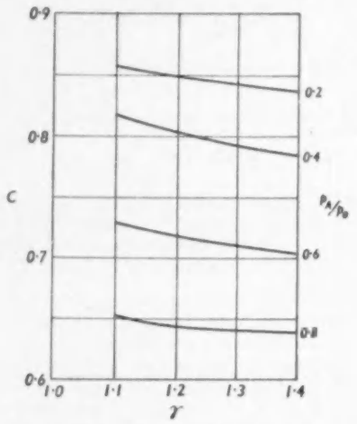

Fig. 17—Effect of γ on coefficient of discharge

there might be some small increase in the coefficient of discharge with temperature. In these experiments, over a temperature range 70 deg. to 550 deg. Fah., the maximum variation was 3 per cent. For high pressure ratios the variation in the coefficient of discharge with temperature was exceedingly small.

Acknowledgments

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References

[1] B.S.S. 1042 : 1943, "Flow Measurements."
[2] Buckingham, E. (1931), "Note on the Contraction Coefficients of Jets of Gas," Bureau of Standards. *Journal of Research*, Vol. 6, page 765.
[3] Jobson, D. A. (1955), "On the Flow of a Compressible Fluid Through Orifices," *Proc. I. Mech. E.*, Vol. 169, page 767.
[4] Wallace, F. J., and Mitchell, R. W. S. (1952), "Wave Action Following the Sudden Release of Air Through an Engine Port System," *Proc. I. Mech.*, Vol. 1B, No. 8, page 343.
[5] Chaplygin, S. A. (1904), "On Gas Jets." *Sci. Annals.*, Imp. Univ. of Moscow, Phys.-Math., Div. 21.
[6] Lighthill, M. J. (1953), "The Hodograph Transformation," "Modern Developments in Fluid Dynamics," "High Speed Flow," (Ed. L. Howarth), Vol. 1, page 222, Oxford University Press, 1953.
[7] Busemann, A. (1933), "Die expansionsberichtichtigung der Kontractionziffer von Blenden," *Forsch. Ing. Wes.*, Vol. 4, page 186.
[8] Busemann, A. (1937), "Hodagraphenmethode der Gas dynamik," *Z.A.M.M.*, Vol. 17, page 73.
[9] Shapiro, A. H. (1954), *The Dynamics and Thermodynamics of Compressible Fluid Flow*, The Ronald Press Co., New York.
[10] Southwell, R. V., and Vaisey, G. (1948), "Relaxation Methods Applied to Engineering Problems: XII Fluid Motions Characterised by Free Streamlines," *Phil. Trans. Roy. Soc.*, Series A, Vol. 246, page 117.
[11] Witte, R. (1930), "Durchflusszahlen von Düsen und Staurändern," *T.M.T.*, Vol. 1, page 34.
[12] Witte, R. (1931), "Dies Strömung durch Dusen und Blenden," *T.M.T.*, Vol. 2, page 291.
[13] Ruppel, G. (1930), "Einfluss der Expansion auf die Kontraction hinter Staurändern," *T.M.T.*, Vol. 1, page 152.
[14] Nusselt W. (1932), "Die Strömung Von Gasen du Blenden," *Forsch. Ing. Wes.*, Vol. 3, page 11.
[15] Callaghan, E. E., and Bowden, D. T. (1949), "Investigation of Flow Coefficients of Circular, Square and Elliptical Orifices at High Pressure Ratios," N.A.C.A. Technical Note, 1947.

Seismic Mountings for Large Machine Tools

By J. A. MACINANTE*

In the design of seismic mountings for the isolation of large precision machine tools from the site vibration, the normal practice is to use isolators of a given type and load-rating throughout, and to locate them in a common horizontal plane. The number of isolators and their plan-layout may differ greatly from one mounting to another as illustrated in three examples. The main design task is the calculation of the natural frequencies. The purpose of this article is to show that the six natural frequencies for any such mounting can be calculated without difficulty if the layout of the isolators satisfies certain simple conditions, derived in the article, which determine the loading of the isolators and the coupling of the vibration modes. It is shown that if these conditions are met, two of the natural modes are uncoupled and can be found from elementary formulae, and the other four occur as two coupled pairs which can be found directly from existing dimensionless curves (Crede) for a four-isolator symmetrical mounting.

EXPERIENCE has shown that the common practice of fixing a large precision machine tool directly on a concrete block set in the ground may be unsatisfactory if the site receives much vibration from neighbouring activities. Increasing use is being made of special mountings which isolate the machine more effectively from the site vibration. The elementary principle of seismic mounting has been known for a long time ; if the equipment be regarded as a rigid body it is simply necessary that the natural frequencies of the mounting be made much lower than the site-vibration frequencies. This is done by supporting the equipment on suitable springs or isolators.

The non-rigidity of actual equipment calls for consideration of the critical frequencies of the equipment in relation to the mounting natural frequencies. For example, Crede (1951, page 146) states that the ratio of mounting frequencies to the critical frequencies of the equipment should not exceed one-half. The non-rigid-body criterion is the subject of a current study and is not discussed further in the present article. Whatever the criterion, the design task is to ensure that the natural frequencies of the mounting will have acceptable (low) values, and the object of this article is to show how the six natural frequencies of any mounting likely to be proposed for a large machine tool can be computed without difficulty in the design office. Although in this article the reference is to machine tools, the results are applicable to any instrument or equipment mounting which meets the stated conditions.

As far as the author is aware, it has not been realised hitherto that the natural frequency calculations for a mounting having any number of identical co-planar isolators in an unsymmetrical layout in the plane could be reduced to the simple terms presented in this paper.

Formulae and curves have been given by various authors (see Macinante (1958, page 9)) for the natural frequencies of a rigid body on four springs located at base positions symmetrical about the two vertical principal planes of the body. Methods have been given also for the completely general case, in which there is no restriction on the properties or location of the isolators, and which therefore may require the solution of six simultaneous equations (e.g. Ker Wilson (1959, page 70) ; Lidin (1959) ; Macduff and Curreri (1958, page 155)).

The author has found that the natural frequencies of mountings satisfying the following conditions can be evaluated without recourse to the general procedure. On the contrary, the results come directly from the symmetrical-four-isolator data. The conditions are :

(*a*) That all the isolators have nominally the same stiffness properties.

(*b*) That they are in common horizontal plane in any arrangement, not necessarily symmetrical, in which they are equally loaded.

(*c*) That a natural vibration in a vertical plane (e.g. rocking) is not accompanied by motion normal to that plane.

The first two conditions are usually specified as a matter of routine design. The third involves no difficulty as shown later. The smallest practicable number of isolators is three, and there is no theoretical upper limit. Three large mountings in Australian engineering works are described briefly to show that the treatment is sufficiently general to cover a wide range of mountings. A survey of seismic mountings and of the literature on vibration and shock isolation in general has been published elsewhere (Macinante, 1958), and therefore the present article does not include any background material.

Notation

The principal notation is as follows :

(*a*) The seismic mass :
- $M = W/g$—Total seismic mass (machine plus baseblock), assumed to be rigid.
- W—Total load on isolators.
- g—Gravitational acceleration.
- $I = M\rho^2$—Moment of inertia of seismic mass about axis denoted by a suffix.
- ρ—Radius of gyration about axis denoted by a suffix.

(*b*) The isolators :
- n—Number of isolators.
- k_{xy}—Stiffness of an isolator in any direction in horizontal xy plane.
- k_z—Vertical stiffness of an isolator.
- $\eta = k_{xy}/k_z$—Ratio of horizontal to vertical stiffness.
- x_r, y_r, Z—Co-ordinates of r^{th} isolator with reference to the axes Ox, Oy, Oz defined below.
- d_r—Radial distance to r^{th} isolator from Oz axis.
- X, Y—Root-mean-square distance of isolators from yz and xz planes respectively.
- Z—Vertical distance from xy plane to horizontal elastic plane of isolators. The latter is defined to be that horizontal plane in which a force applied to the supported body causes horizontal displacement without rotation about a horizontal axis. It will be noticed that the z axis is downward and Z is positive (or zero) in large mountings of practical interest.

(*c*) The motion of the seismic mass :
- $\Omega = 2\pi f$—Circular frequency in mode identified by suffix.
- f—Cyclical frequency.
- Ox, Oy, Oz—Rectangular axes coincident with principal axes of seismic mass M when in its rest position.
- x, y, z—Displacements in centre of gravity (c.g.) of seismic mass.
- α, β, γ—Rotations about Ox, Oy, Oz respectively.

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Mounting Conditions

The assumed conditions are listed in more detail and followed by a discussion of the significance of the load-sharing and coupling conditions, items (vi) and (vii) below. Examples are then given of typical mountings to which the analysis applies.

(*a*) *Assumptions.*—(i) All isolators in a

given mounting have identical stiffness properties.

(ii) The stiffness of an isolator in any horizontal (radial) direction has a constant relationship to its vertical (axial) stiffness.

(iii) The load/deflection relationship is linear for small displacements about the equilibrium position. This will not be questioned for helical metal springs but requires justification for other materials, which may be non-linear. The vibratory displacements in service are small (usually less than 0·001in) compared with the static displacement (usually more than 0·2in) over which the non-linearity may be appreciable. Therefore the stiffness can be taken to be linear at the value given by the slope of the load/deflection curve at the working deflection. Since the stiffness of some materials is greater under dynamic conditions, it will be understood that the stiffness is that appropriate to the dynamic conditions.

(iv) The damping of the isolators can be ignored in the derivation of the natural frequencies.

(v) All isolators have their main (axial) loading direction vertical and are seated on a common horizontal plane.

(vi) All isolators are equally loaded.

(vii) Coupled vibration in a vertical plane is not accompanied by "cross-coupling" involving motion normal to that plane.

(*b*) *Load-Sharing Conditions.*—Suppose that a rigid body having a plane lower face is to be put on a given number of identical isolators which rest on a horizontal plane in any layout. What condition must be satisfied if the isolators are to have equal vertical loading ?

Clearly all must have the same deflection when the body rests on them, and hence the lower surface of the body must remain horizontal. This is possible only if the line of action of the resultant R of the reactions (R_1, R_2, &c.) from all the isolators passes up through the centre of gravity (O) of the body (Fig. 1).

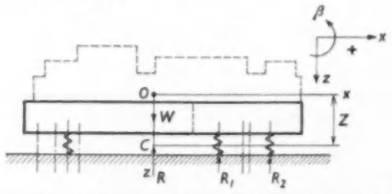

Fig. 1—Elevation of machine tool (in broken outline) on seismic block supported by spring isolators

It is shown in Appendix A that the resultant of a system of equal vertical reactions acts vertically through a point which can be identified as the c.g. of a system of equal masses having the same plan-layout as the isolators. (Figs. 1 and 2). Therefore, the condition

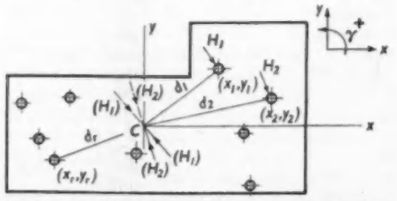

Fig. 2—Plan of the seismic block and isolators of Fig. 1

for equal loading is that the point C, the c.g. of the isolators regarded as a system of point masses, must be vertically below O, the c.g. of the body. With reference to the axes defined, the load-sharing condition is

$$\Sigma_n x_r = 0,\ \Sigma_n y_r = 0 \quad . \ . \ . \quad (1)$$

In actual mountings the isolators are not located between two truly plane surfaces, and therefore each isolator is adjusted, either by packing or loading screw, so that its deflection is within certain limits.

(*c*) *Coupling Conditions.*—As a consequence of the load-sharing condition the natural vertical vibration is uncoupled. This is because the inertial reaction, which acts through the c.g. of the body, is balanced by a co-linear resultant from the isolators and hence the block does not tilt. A further and perhaps unexpected result is that the rotational mode about the vertical axis is uncoupled. This is shown as follows : consider the body to be displaced through a positive angle γ about Oz (Fig. 2). The reactions H_1, H_2, &c., at the isolators have the magnitudes

$$H_1 = \gamma k_{xy} d_1,\ H_2 = \gamma k_{xy} d_2,\ \&c.$$

This system of reactions is equivalent to a system of negative couples shown in the full-lines, namely,

$$-\gamma k_{xy} d_1^2,\ -\gamma k_{xy} d_2^2,\ \&c.,$$

together with the system of concurrent forces (H_1), (H_2), &c., shown by the broken-line arrows acting at C. If the latter are in equilibrium there is no resultant force acting to displace the block in a plane normal to the z axis.

That the forces at C are in equilibrium can be shown as follows. Each is perpendicular to a radial line d_1, d_2, &c., and, since the forces are respectively proportional to these radii, it will be sufficient to show that the radial lines regarded as a system of vectors are in equilibrium. They are, as a consequence, of the geometrical conditions stated in equations (1).

Now consider a free rocking motion of the body in which the c.g. is displaced in the x direction (Fig. 3) and at the same time there

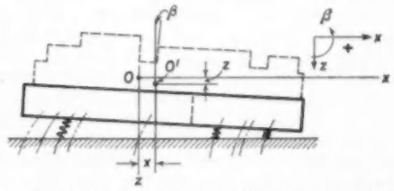

Fig. 3—Displacement of seismic block in vertical (XZ) plane

is a coupled rotation β about Oy. At the end of an excursion to the right, the inertia force through O in the x (positive) direction is opposed by the horizontal x reactions from all the isolators. Following similar reasoning in relation to the horizontal x reactions of the isolators to that used for the vertical reactions, it can be seen that if the algebraic sum of the y co-ordinates is zero the isolators will have equal reactions in the x (negative) direction and there will be no coupling between this rocking motion and rotation about Oz.

However, there may be coupling about Ox ; that is, the rotation about Oy may be accompanied by some rotation about Ox. The condition that such cross-coupling should not occur is now derived. Suppose the block be rotated through a small angle β about Oy. The change δR_r in the vertical reaction of any isolator is $\delta R_r = k_z \beta x_r$.

There will be no cross-coupling about Ox if the total moment of the changes in reactions δR_r about the Ox axis is zero.

That is if

$$\Sigma_n \delta R_r y_r = 0$$

i.e.

$$k_z \beta \Sigma_n x_r y_r = 0$$

or

$$\Sigma_n x_r y_r = 0 \quad . \ . \ . \ . \quad (2)$$

Thus the condition for no cross-coupling about the horizontal axes is that the algebraic sum of the products of the horizontal co-ordinates of the isolators should be zero.

The following physical checks on this criterion may be of interest.

(i) A mounting having all isolator positions along the axes in the plan lay-out, and satisfying equations (1) would obviously have no cross coupling. This is consistent with the criterion in equation (2) since for every isolator either x_r y_r is zero, therefore every x_r y_r product is zero. It follows that in setting out on the drawing-board the isolator positions, any positions on the axes can be manipulated to balance equations (1) without affecting the balance of equation (2).

(ii) If all isolators are in the first and third quadrants it is possible to satisfy equations (1) but it can be visualised physically that an applied couple (e.g. positive) about Oy would be accompanied by some rotation (positive) about Ox. Since all contributions to the xy sum are positive, the cross-coupling would be expected. Conversely, if all isolators are in the second and fourth quadrants the xy sum is negative and it can be seen physically that the positive torque about Oy would now involve a negative rotation about Ox.

(*d*) *Typical Mountings.*—Three mountings are now described which are typical of those to which the present analysis applies. These were designed by the establishments concerned or their design consultants, after talks with the author on the theoretical principles and relative merits of the alternatives. The final choice was made by the firm after consideration of the relative costs, the available isolators, the severity of the site vibration and other practical matters.

(i) The design shown in Fig. 4 was adopted by Cockatoo Docks and Engineering Company Pty., Ltd., Cockatoo Island, Sydney, for isolating a Société Génévoise "Hydroptic" 8 jig boring machine from vibration caused

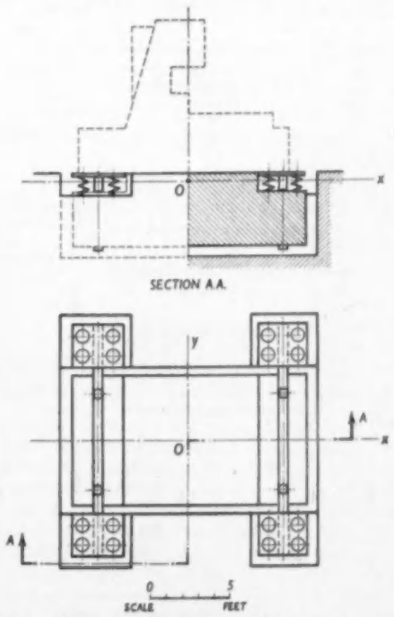

Fig. 4—Seismic mounting with fully symmetrical layout of the isolators

by the heavy engineering activities carried out on the island.

The machine (20-ton) rests on a baseblock (30 ton) and the whole is supported by sixteen helical springs in four sets of four arranged symmetrically in plan about the vertical

axis through the c.g., and located vertically so that their elastic plane nominally coincides with the horizontal plane through the c.g. The springs were made from 1¼in diameter spring steel with a mean coil diameter of 9in and working deflection 2in for a load of 3 tons.

(ii) In the mounting shown in Fig. 5

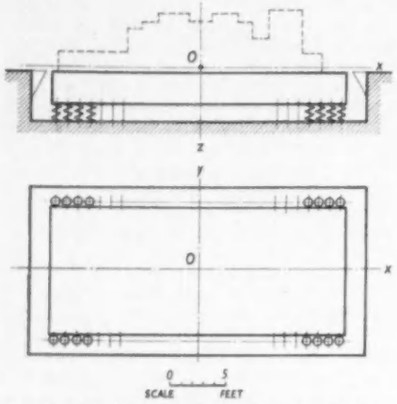

Fig. 5—Seismic mounting with the isolators symmetrical about two vertical planes

commercial rubber-in-shear isolators were used in two rows along the base of a seismic block on which was installed a Churchill roll grinding machine at Austral Bronze Company Pty., Ltd., Alexandria, N.S.W. A total weight of 115 tons, comprising a base-block (66 tons), the machine (39 tons) and workpiece (maximum 10 tons), is supported on fifty-four isolators in two rows of twenty-seven as shown.

(iii) This mounting (Fig. 6) is similar to the second, but for practical reasons the layout

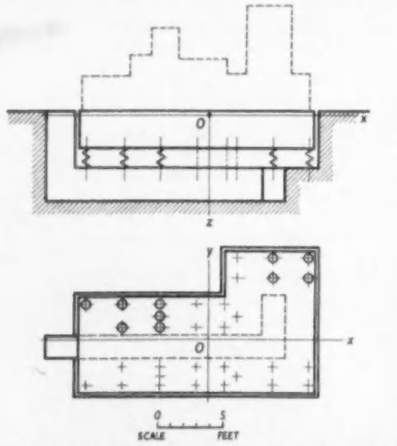

Fig. 6—Seismic mounting with unsymmetrical layout of the isolators

of isolators is unsymmetrical. It was installed by the Australian Department of Supply at the Ordnance Factory, Bendigo, Victoria, for the isolation of a Maag gear grinding machine. A total weight of 53 tons, comprising an " L "-shaped block (37 tons) and the machine (16 tons), is supported on thirty-two rubber-in-shear isolators as shown. The tunnel under this mounting is for access to the isolators. In the other mountings access for (i) was above the floor and for (ii) was in the space around the seismic block.

Natural Frequencies

The natural frequencies are derived for an unsymmetrical layout of the isolators satisfying the conditions discussed above. The results for mountings having planes of symmetry follow as special cases.

(*a*) *Unsymmetrical Mountings.*—(i) Vertical z motion : Since the vertical free vibration is uncoupled, the natural frequency in this mode is given by the well-known relationship between the mass and the total restoring force, namely :

$$\Omega_z=\sqrt{\left(\frac{nk_z}{M}\right)},\ \text{or}\ f_z=\frac{1}{2\pi}\sqrt{\left(\frac{nk_zg}{W}\right)} \quad . \quad (3)$$

(ii) Rotation about Oz : The rotational mode about the vertical axis has been shown to be uncoupled. The restoring torque due to a rotation γ about that axis (see Fig. 2) is

$$-\gamma k_{xy}\Sigma_n d_r^2.$$

The summation

$$\Sigma_n d_r^2=\Sigma_n(x_r^2+y_r^2),$$
$$=n(X^2+Y^2),$$

where X and Y are the root-mean-squared values of the x and y co-ordinates respectively.

Using the equation analogous to (3) for rotational motion, the natural frequency is

$$\Omega_\gamma=\sqrt{\left\{\frac{k_{xy}n(X^2+Y^2)}{I_z}\right\}} \quad . \quad (4)$$

It is convenient (after Crede 1951) to express the natural frequencies as ratios of the vertical value. Thus, using Equations (3) and (4) and introducing ρ and η as defined

$$\frac{\Omega_\gamma}{\Omega_z}=\sqrt{\left\{\frac{\eta_\gamma(X^2+Y^2)}{\rho_z^2}\right\}} \quad . \quad . \quad . \quad (5)$$

(iii) *Coupled modes in xz Plane* : Let the seismic body perform a simple rocking motion (Fig. 3). At a given instant the c.g. is displaced by small amounts x and z which are positive, and the body has rotated an amount β which, with the adopted sign convention, is negative.

For small β all isolators have the same horizontal deflection, which can be written $(x+Z\beta)$, for it is greater or less than x according as β is positive or negative, since Z is positive. Although the following analysis is valid for negative values of Z further attention will be given only to positive (and finally zero) values of Z because negative values are not of interest in the present context. Therefore the equation of x motion is

$$M\ddot{x}=-nk_{xy}(x+Z\beta). \quad . \quad . \quad (6)$$

The moment about Oy of the horizontal forces at the isolators is $-nk_{xy}Z(x+Z\beta)$.

The vertical deflection of any (r^{th}) isolator is $(z-x_r\beta)$. However, since the vertical vibration is uncoupled the z component at any instant is the same for all isolators and does not affect the rotation. Therefore z can be omitted and the moment due to the vertical deflection of the isolators caused by the rotation β is $-k_z\beta\Sigma_n x_r^2$ which equals $-k_z\beta nX^2$.

Therefore the equation for the β motion is

$$I_y\ddot{\beta}=-nk_{xy}Z(x+Z\beta)-nk_zX^2\beta \quad . \quad . \quad . \quad (7)$$

It is known from observations that in this rocking motion the periodic x displacement of the c.g. and coupled β rotation have the same frequency, which will be denoted Ω_c. It can also be verified experimentally that motion can be maintained in either of two modes :

(1) Lower rocking mode ; with adopted sign convention, β maximum negative when x maximum positive (as in Fig. 3).

(2) Higher rocking mode, β maximum positive when x maximum positive.

Therefore it is assumed that

$$x=x_o\sin\Omega_c t\ ;\ \beta=\pm\beta_o\sin\Omega_c t$$

and hence

$$\ddot{x}=-\Omega_c^2x_o\sin\Omega_c t\ ;\ \ddot{\beta}=\mp\Omega_c^2\beta_o\sin\Omega_c t$$

Making these substitutions in equations (6) and (7) and re-arranging, the equations to be satisfied become

$$(-M\Omega_c^2+nk_{xy})x_o\pm nk_{xy}Z\beta_o=0$$
$$nk_{xy}Zx_o\mp(I_y\Omega_c^2\mp nk_{xy}Z^2\mp nk_zX^2)\beta_o=0$$

Now making the further substitutions

$$\eta=k_{xy}/k_z\ ;\ I_y=M\rho_y^2\ ;\ \Omega_z^2=nk_z/M$$

the equations become

$$\left(-\frac{\Omega_c^2}{\Omega_z^2}+\eta\right)x_o\pm\eta Z\beta_o=0$$

$$\eta Zx_o\mp\left(\rho_y^2\frac{\Omega_c^2}{\Omega_z^2}\mp\eta Z^2\mp X^2\right)\beta_o=0$$

in which the upper and lower sign relate to the higher and lower mode respectively.

Elimination of either x_o or β_o in these equations leads to the following quadratic in the dimensionless ratio $\left(\frac{\Omega_c}{\Omega_z}\right)^2$

$$\left(\frac{\Omega_c}{\Omega_z}\right)^4-\left\{\eta\left(1+\frac{Z}{\rho_y^2}\right)+\frac{X^2}{\rho_y^2}\right\}\left(\frac{\Omega_c}{\Omega_z}\right)^2+\frac{\eta X^2}{\rho_y^2}=0$$

The solution is

$$\left(\frac{\Omega_c}{\Omega_z}\right)^2=\tfrac{1}{2}\left\{\xi\pm\sqrt{\left(\xi^2-\frac{4\eta X^2}{\rho_y^2}\right)}\right\}$$
$$. \quad . \quad . \quad . \quad (8)$$

where

$$\xi=\eta\left(1+\frac{Z^2}{\rho_y^2}\right)+\frac{X^2}{\rho_y^2} \quad . \quad . \quad . \quad (9)$$

This is the same as Crede's result for a four isolator mounting, except that the root-mean-squared value X has replaced the " b " used by Crede for the constant distance of each isolator from the yz plane (Crede, 1951, page 53).

In Fig. 7, a few of Crede's curves for the four-isolator case are reproduced with the notation of the present article. The coupled frequencies in the xz plane are read off as follows. An abscissa is calculated from the given or estimated values of ρ_y and η and the computed root-mean-squared value X of the x locations of all the isolators. For this abscissa ordinates are read off the two curves for the appropriate (Z/ρ_y) value. The required values of (Ω_c/Ω_z) are extracted by dividing each ordinate by (ρ_y/X). Since Ω_z is known from equation (3), the two numerical values of Ω_c are easily evaluated.

A suggested procedure for design-office calculations is outlined in Appendix B.

(iv) *Coupled modes in yz plane* : The same argument applies and the result is obtained by using ρ_z and Y instead of ρ_y and X respectively. The actual values of Ω_c in yz plane are then found as before, using the same set of curves for the four-isolator case.

(*b*) *Mountings with Planes of Symmetry.*—The designer will use a symmetrical plan-layout unless the circumstances of the particular mounting make this impracticable as in example (iii) above. Whether or not the mounting is symmetrical is of little consequence. If there are planes of symmetry the calculation of the root-mean-squared values X and Y is merely a little easier. Thus if the isolators are in two rows equidistant from a vertical plane such as the plane xz in Fig. 5 the value of Y is simply half the distance between the rows.

If the horizontal elastic plane of the isolators coincides with the xy plane as in Fig. 4, $Z=0$ and equations (6) and (7) reduce to

$$M\ddot{x}=-nk_{xy}x\ ;\ I_y\ddot{\beta}=-nk_zX^2\beta$$

which respectively give the familiar results for the now uncoupled x and β modes

$$\Omega_x=\sqrt{\left(\frac{nk_{xy}}{M}\right)}$$

and

$$\Omega_\phi = \sqrt{\left(\frac{nk_z X^2}{I_y}\right)} \quad . \quad . \quad . \quad (10)$$

Or, as ratios of the vertical natural frequency,

$$\frac{\Omega_x}{\Omega_z} = \sqrt{\gamma_i}$$

and

$$\frac{\Omega_\phi}{\Omega_z} = \frac{X}{\rho_y} \quad . \quad . \quad . \quad . \quad (11)$$

This result is confirmed by substituting $Z=0$ in equations (8) and (9), and will be recognised in the lines OA and BC in Fig. 7.

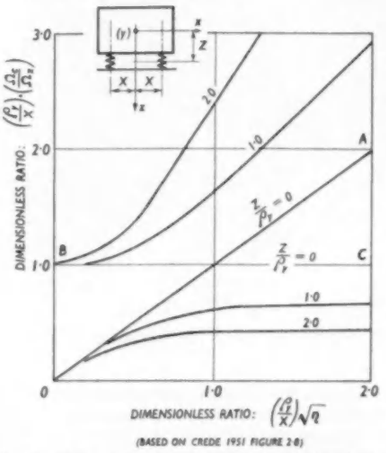

Fig. 7—Dimensionless curves for coupled frequencies in vertical plane of symmetry

Conclusions

The natural frequencies have been derived for seismic mountings of the class, illustrated by three examples, in which all the isolators have nominally the same stiffness properties and are in a common horizontal plane. The number of isolators and their positions in the plane may vary widely subject only to two general conditions which can easily be met. These are (*a*) that the isolators are equally loaded, and (*b*) that coupled (rocking) vibration in each vertical principal plane is not accompanied by motion normal to the plane.

It has been shown that condition (*a*) is satisfied for any layout of isolators if their " centre of gravity " regarded as a system of equal point masses is placed vertically below the c.g. of the seismic mass. It was found that this resulted in an uncoupled rotational mode about the vertical axis in addition to the obviously uncoupled vertical mode.

The criterion found for condition (*b*) was that the algebraic sum of the products of the isolator co-ordinates should be zero with reference to the principal axes in the plan-layout.

For the calculation of the natural frequencies, it has been shown that the two uncoupled values can be found by the application of elementary formulae, and the other four by the use of existing data for a symmetrical four-isolator mounting. For the latter, it was shown that the root-mean-square distance of the isolators from the appropriate vertical plane is substituted for the common distance of each of the four isolators. This was proved for the general unsymmetrical layout, and the simplification resulting from planes of symmetry was shown.

References

Crede, C. E. (1951), " Vibration and Shock Isolation," John Wiley and Sons, New York ; Chapman and Hall, London.

Ker Wilson, W. (1959), " Vibration Engineering," Charles Griffin and Co., Ltd., London.

Lidin, L. G. (1959), " On Helical-Spring Suspension," Chalmers University of Technology, Sweden, No. 210.

Macduff, J. N., Curreri, J. R. (1958), " Vibration Control," McGraw Hill Book Company, Inc., New York, Toronto, and London.

Macinante, J. A. (1958), " Vibration and Shock Isolation : A Survey," C.S.I.R.O., Aust. Nat. Stand. Lab., Tech. Paper No. 10.

Appendix A

Static Equilibrium of Seismic Mass

Consider the static equilibrium of a rigid body resting on n identical linear isolators located between two planes, one fixed in the body and the other representing a rigid base. Let the co-ordinates of the isolators with reference to rectangular axes in a horizontal reference plane be (x_1, y_1) ; (x_2, y_2), &c., and let the vertical reactions be R_1, R_2, &c., respectively. It is known from first principles that the resultant of any pair of parallel forces, namely R_1 acting at A and R_2 at B, is a parallel force (R_1+R_2) acting at a point on the line AB situated at $AB.\ R_2/(R_1+R_2)$ from A. Hence the resultant (R_1+R_2) of the forces R_1 and R_2 has co-ordinates.

$$\left\{x_1+(x_2-x_1)\frac{R_2}{R_1+R_2}\right\}, \left\{y_1+(y_2-y_1)\frac{R_2}{R_1+R_2}\right\}$$

Now combining with R_3 (x_3, y_3) and neglecting the y co-ordinate for which the analysis is similar, the x co-ordinate of the resultant $(R_1+R_2+R_3)$ is

$$x_{123} = \left\{x_1+(x_2-x_1)\frac{R_2}{R_1+R_2}\right\} + \left[x_3-\left\{x_1+(x_2-x_1)\frac{R_2}{R_1+R_2}\right\}\right]\frac{R_3}{R_1+R_2+R_3}$$

which reduces to

$$x_{123} = \frac{x_1R_1+x_2R_2+x_3R_3}{R_1+R_2+R_3}$$

Continuing in this way it can be shown that the resultant for n springs has co-ordinates

$$\frac{\Sigma_n x_r R_r}{\Sigma_n R_r}, \frac{\Sigma_n y_r R_r}{\Sigma_n R_r}$$

If R is the same for all isolators, and if $\Sigma_n x_r = 0$, $\Sigma_n y_r = 0$ both co-ordinates are zero.

In other words, the resultant passes through the origin of the rectangular axes about which the sums of the co-ordinates of the isolator positions are zero. This origin can be regarded as the centre of gravity of a system of point masses having the same co-ordinates as the isolators.

Appendix B

Calculation Procedure

The following general procedure is suggested for use in the design office, bearing in mind that precise results are not required, and that some of the data may be only a rough estimate.

(1) Estimate the weight and centre of gravity of the total mass on the isolators.

(2) Adopt the c.g. as the origin of three rectangular axes. Strictly, these should be the principal axes of inertia of the mass, but for the present purpose the axes can be taken as x horizontal and parallel to the ways or the centre line of the machine, y horizontal, perpendicular to x and z vertical.

(3) Estimate (by inspection) the radii of gyration about these axes. If not confident in the estimate, upper and lower limits can be taken and the results worked out for the limits.

(4) For the load rating of a given type of isolator under consideration, calculate the required number of isolators and make a tentative layout.

(5) Modify the positions so that the c.g. of the isolators regarded as a system of equal point masses is vertically below the c.g. of the seismic mass (i.e. satisfy Equations (1) of the paper).

(6) Check the algebraic sum of the xy products and modify the layout so that Equation (2) is also satisfied. An exact balance to zero is not necessary. Calculate the root-mean-squared values X and Y.

(7) Find values for the stiffness of the isolators in the vertical and horizontal directions. For metal springs the values can be calculated and for rubber isolators, the data should be supplied by the manufacturer.

(8) Find the position of the elastic plane, hence find Z. Again it may be necessary to use limits to cover the range of uncertainty.

(9) Use Equation (3) to find the vertical natural frequency, and Equation (4) or (5) for the rotational frequency about the vertical axis.

(10) Use Crede's curves for the four-isolator mounting to evaluate the coupled-frequencies in the xz and yz planes, as detailed in the paragraphs following Equations (8) and (9) in the paper.

Note on Indicating the Free Piston Engine

By G. WALKER*

Many types of mechanical and electronic devices have been developed for indicating conventional reciprocating engines and the technique of their use is well established. However, except in those cases where the base of the diagram is not controlled by the engine few of these indicators can be used without some modifications with a free piston engine. The purpose of this article is to discuss a modification to the Dobbie McInnes " Farnboro " indicator which would allow its use with free piston engines with the object of producing permanent work diagrams directly.

The Free Piston Engine: Applications

THE free piston engine in its various forms has been well documented by Eichelburg,[1] Beale,[2] Farmer[3] and others. It will be sufficient to say here that at the present time it is used both as (1) an air compressor; (2) a gas generator or gasifyer. In this application the machine produces hot pressurised gas which is subsequently expanded in a power turbine.

As an air compressor the machine is attractive because of its small size and weight coupled with high output and efficiency compared with conventional reciprocating compressors.

As a gas generator used in conjunction with a power turbine, the combination has a low specific weight compared with two- or four-stroke diesel engines, but the thermal efficiency at the present stage of development is slightly lower. On the other hand, compared to a gas turbine with rotary compressor and combustion chamber the efficiency is high. One reason for this is that the cycle of operations is such that

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it allows the use of a high maximum (instantaneous) temperature in the engine cylinder compared to the highest temperature which can be used in the gas turbine.

Cycle of Operations

For those unfamiliar with the free piston engine and its mode of operation attention is directed to Fig. 1, showing the general

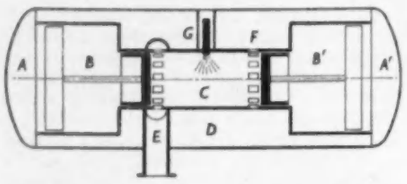


Fig. 1—Generalised configuration of free piston engine

free piston configuration. *C* is the engine space which operates on a two-stroke internal combustion compression ignition cycle. The inlet parts are at *F* and the exhaust ports at *E*. Fuel is supplied through one or more injectors at *G* when the two pistons are close together. As combustion proceeds the high pressure generated causes the two pistons to move apart. These "diesel" pistons are rigidly connected to compressor pistons operating in the cylinders *AB* and *A'B'* and which compress air contained in these spaces. If the air to be subsequently used outside the machine is compressed in *A* and *A'* the machine is an outward compressing type or alternatively, if it is compressed in *B* and *B'* the machine is an inward compressing type. In both types "cushion" cylinders must be used to store sufficient energy (in the form of compressed air) to return the pistons on the inward stroke, thereby compressing the fresh charge in *C* and completing the cycle. The ideal pressure volume diagrams for each space in an inward compressing type of machine are shown in Fig. 2. Here *A* and *A'* act as the cushion cylinders and the useful air is compressed in *B* and *B'*. If the machine is used as an air compressor most of the compressed air is passed from *B* and *B'* to a receiver while some is supplied to the scavenge belt *D* and is used to scavenge the engine and supply the fresh charge. Alternatively, a special cylinder can be used to supply air (at a lower pressure) for scavenging and all of the relatively highly compressed air from *B* and *B'* is then usefully employed. Free piston compressors can be single-stage machines, i.e. Pescara-Muntz P.42 and DAC.130 types or can be compounded with up to four or more stages as in the Junkers type 4FK–115.

When used as a gas generator most or all of the air compressed is passed into the scavenge belt and hence through the engine cylinder *C*, either as scavenge air or as hot residual products, to a receiver and is subsequently expanded in a power turbine. In this form the engine is highly supercharged and exhausts with a high back-pressure (which is the turbine inlet pressure).

The free piston engine is capable theoretically of operating with the two sets of pistons completely unrestrained mechanically. In practice, however, in order to maintain

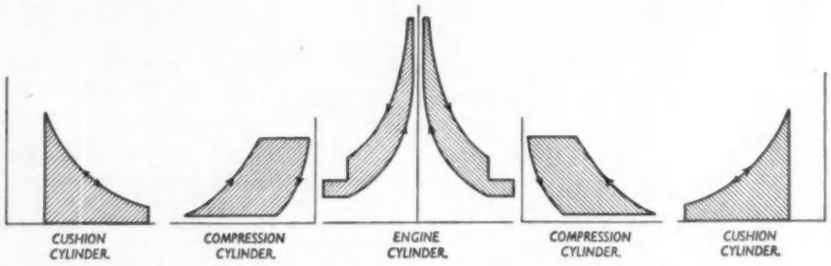


Fig. 2—Theoretical pressure-volume diagrams for an inward compressing type free piston engine

synchronous operation, the pistons are connected by a linkage. Most of the linkages used have a shaft at the centre which oscillates when the engine is running. This shaft is particularly useful for driving auxiliaries such as fuel and oil pumps.

Indicating

Since the output of a free piston engine is in the form of pressurised gas it is difficult to express in terms familiar to engineers. In order to investigate the operation and efficiency of each of the various elements comprising the complete machine it is desirable to measure work diagrams from all of the spaces mentioned above. This may be difficult since the various spaces (particularly the engine cylinder) are not easily accessible and also the only driving shaft available (at the centre of the synchronising linkage) oscillates and does not rotate. An example of this difficulty of access to the various spaces is found in the Junkers four-stage compressor shown in Fig. 3. The third and fourth compression stages are shrouded by the first and second stages and it is virtually impossible to mount pressure pickups without using exceptionally long passage lengths.

This difficulty of reasonable access coupled with the problem of arranging for an indicator drive precludes the use of reciprocating spring type indicators. As far as the writer is aware most of the diagrams obtained so far have been measured using electronic indicators. One form of equipment available for this purpose is the Standard Sunbury type F engine indicator used in conjunction with a special unit developed by E. S. L. Beale. This unit is driven by the oscillating shaft of the synchronising linkage and produces a signal proportional to the piston position.

The value of electronic indicators is well established, particularly in the study of high-frequency phenomena. However, in order to obtain a permanent record it is usually necessary to photograph the image on a cathode-ray screen which may be inconvenient and further, without considerable experience, it is sometimes difficult to reproduce or interpret the results. Accurate diagrams can be obtained by means of balancing air pressure giving two points on the diagram per cycle, but the procedure tends to be lengthy and tedious in use.

In an attempt to by-pass these difficulties in the case where simple work diagrams only were required a suggestion has been made which would allow the use of a modified Dobbie McInnes "Farnboro" indicator. The proposal was made to the writer by Messrs. Herbert and Milne, of Smiths Dock Company, Middlesbrough, manufacturers of the 1250 gas horsepower GS 34 free piston gas generator.

In conventional applications of the "Farnboro" indicator, shown in Fig 4, the drum is driven by the engine crankshaft which thereby sets up the crankangle base of the diagram. The pressure axis is fixed by a

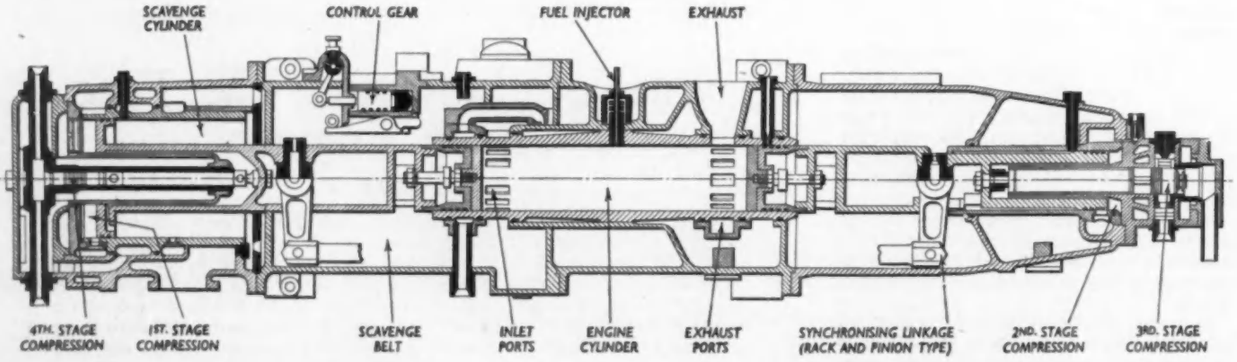


Fig. 3—Simplified cross section through Junkers 4F.K.115 free piston, four-stage intercooled air compressor. Capacity : 60 cubic feet free air per minute. Delivery pressure : 3000 lb per square inch. Speed : 900 cycles per minute

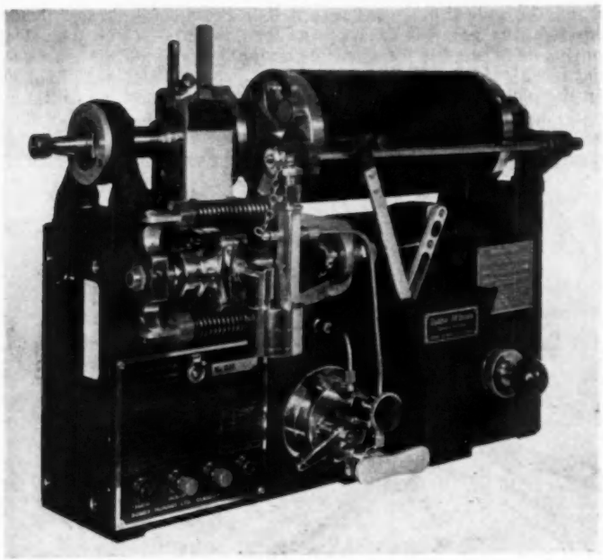


Fig. 4—The Dobbie McInnes "Farnboro" indicator

stylus which moves axially along the drum. The position of the stylus is controlled through a parallel motion mechanism by an applied gas pressure acting on a piston in a cylinder against the resistance of two calibrated coil springs in tension. This same pressure which moves the stylus is applied to the back of a diaphragm in the pressure pickup mounted in or adjacent to the engine. When the pressure in the engine cylinder just exceeds (when increasing) and is just below (when decreasing) the applied pressure the diaphragm moves and respectively makes and breaks a circuit so that a high-voltage pulse is passed to the stylus which causes a spark from the stylus to pass through and perforate the indicator card wrapped around the drum. Two points on the diagram are obtained per engine cycle and the complete diagram is made up from several hundred cycles.

When used with a free piston engine it is proposed the indicator be modified so that :

(1) the stylus is driven by one of the reciprocating parts of the engine attached to the diesel or compressor piston, thereby providing a stroke base for the diagram.

(2) the spring/pressure system be connected to the drum so that as the pressure is increased the drum is caused to move round.

The pressure pickup system would, of course, remain the same.

With this arrangement a permanent pressure volume diagram would be produced directly.

In the past, two objections to the use of the "Farnboro" indicator have been made. These were (*a*) the time delay which elapses between the coincidence of the pressures and the occurrence of the spark and (*b*) the fouling of the diaphragm in the pressure pickup by carbonaceous products of combustion. In conventional applications of the "Farnboro" indicator both these difficulties have been overcome by the use of equipment developed by Mansfield and Cornish[4] and by Hempson and Roach.[5] In the former case use is made of a pressure pickup which produces a small continuous signal, and the timing of the h.t. pulse to the drum is controlled by an "electronic switch" interposed between the pickup and the indicator. A version of this equipment is available commercially and is now used as standard equipment. In the latter case an improved pressure pickup is used in conjunction with an electronic relay. This was initially developed for use on low-speed marine oil engines but has been applied also to high-speed engines and is available commercially.

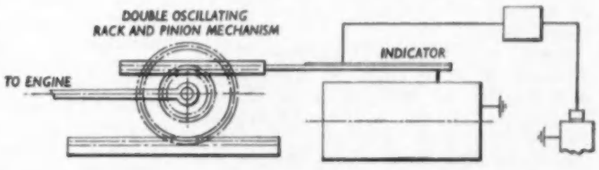


Fig. 5—Arrangement of stroke reducing drive to indicator

Effect of Change in Load

An important characteristic of the free piston engine is that changes in the load are accommodated by a change in stroke of the pistons rather than by a change in the engine speed. In general, as the load is increased the stroke increases and for a constant gas delivery pressure the speed tends to decrease by a small amount. On the other hand, when used with a given turbine, the speed increases with load. An assessment of this change in

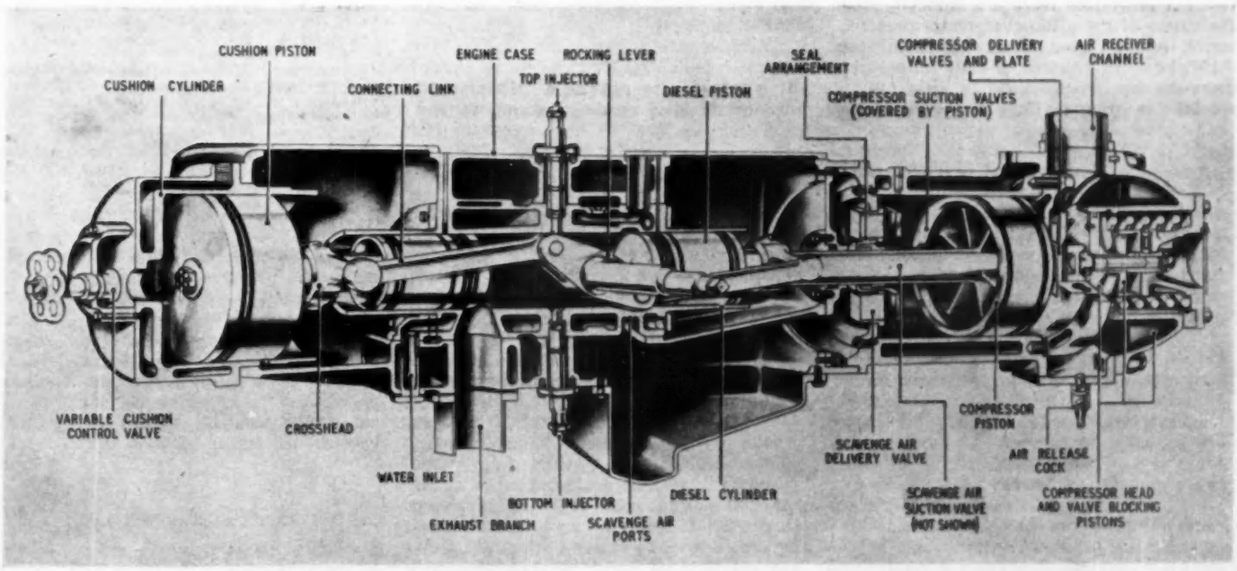


Fig. 6—The Pescara Muntz D.A.C. 130 free piston air compressor

stroke with load is of interest and could be measured using the modified " Farnboro " indicator described above with the addition of a means for driving the drum at a constant known speed. This could be done either electrically or by a clockwork mechanism. A further requirement would be for a regular series of pulses to be passed to the stylus. This, however, is provided in the two " electronic " equipments mentioned above and is used to calibrate the pressure scale.

The diagram produced by the stylus reciprocating as the drum was driven at a slow constant speed would be of approximately sinusoidal form with the peak-to-peak distance being a measure of the piston stroke. To obtain several minutes' engine running time under the changing load conditions a low indicator drum speed would have to be used. A speed of about one-tenth of a drum revolution per minute is suggested. Under these conditions the diagram would be a mass of spark holes with the boundaries of the diagram clearly defining the stroke of the piston against time. The shape of the displacement curve of the pistons would, however, be difficult to assess.

Piston Movement

The pistons in a free piston engine do not move with simple harmonic motion but move in a manner which is akin to a mass mounted on a non-linear spring. A study of the displacement curve for the pistons is interesting since from this can be obtained the piston velocities and accelerations and hence an estimate of the forces involved on the moving parts.

Using the modified " Farnboro " the displacement curve could be measured by arranging for the drum to be driven at a faster speed than that used in the measurement of the change of stroke. This would enlarge the time scale of the diagram and facilitate the analysis.

Applications

It is considered feasible that the modified indicator described above could be used with the three types of free piston engine which have found particular favour in this country, namely, the GS 34 and CS 75 gas generators and the D.A.C.130 air compressor. On the two gas generators there is a difficulty that the stroke of the pistons is greater than the length of the standard size drum of the " Farnboro " indicator. This could be overcome by the provision of either (*a*) a special size drum or (*b*) a stroke reduction gear between the engine and the indicator. One possible form for this reducing gear is shown in Fig. 5. It consists of a double rack and pinion arrangement with the ratio of the number of teeth on the pinions being in the same reduction ratio as the engine stroke and the length of diagram desired.

This difficulty does not exist in the case of the small Pescara-Muntz free piston air compressor shown in Fig. 6, since the stroke of the pistons is limited to about 6in, which is in the capacity of the standard size " Farnboro " indicator drum. This machine is also provided with a convenient arrangement to pick up a drive to the reciprocating stylus of the indicator. This is shown in Fig. 7, which is an internal view of the arrangement of pistons and synchronising linkage. It can be seen that at each compressor piston crosshead there is a slipper operating in guides on the engine casing. It is a simple matter to connect to this reciprocating slipper either a stroke indicator or a drive to the stylus of the indicator. A considerable advantage arises from making use of this slipper since this is moving with the true motion of the piston whereas the oscillation of the shaft at the centre of the linkage is distorted due to connecting-rod obliquity and must be retranslated or some other compensation applied.

Conclusion

It is intended to provide a " Farnboro " indicator modified as described above and used with a P.42 Pescara-Muntz free piston compressor for student use in the Heat Engines Laboratory of King's College, Newcastle upon Tyne. A free piston engine with suitable instrumentation provides an interesting exercise in the analysis of a complex system. In addition, this class of machine has certain characteristics peculiar to itself, and in view of its increasing importance, particularly in marine engineering, it is thought to be a worthwhile item of laboratory equipment.

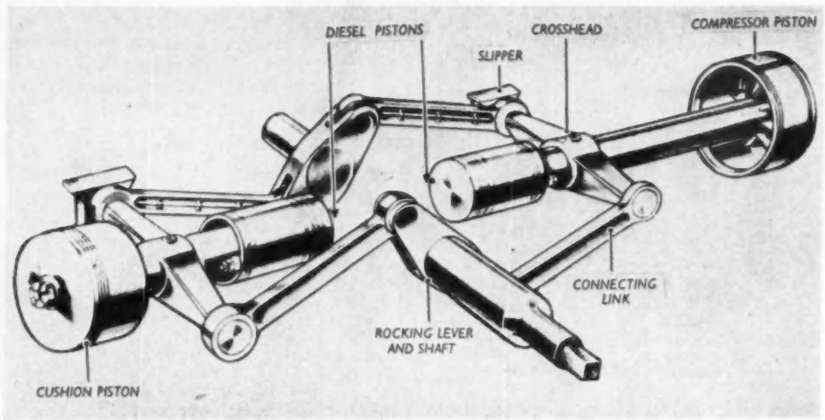


Fig. 7—Arrangement of pistons and synchronising linkage in D.A.C. 130 compressor

Acknowledgments

The writer is indebted to Messrs. Herbert and Milne for the original suggestion, to Messrs. Dobbie McInnes for the loan of a " Farnboro " indicator and for Fig. 4, to Messrs. Mackay Industrial Equipment for Figs. 6 and 7, and to Professor A. F. Burstall for his help and encouragement and for permission to publish this note.

References

[1] Eichelburg, G., " The Free Piston Gas Generator," *Trans. Schweizerische Bauzeitung*, Nos. 48 and 49, November and December, 1948.

[2] Beale, E. S. L., and Watson, P., " Free Piston Gas Generators and Their Applications," D.E.U.A., January, 1956.

[3] Farmer, H. O., " Free Piston Compressor Engines," *Proc. I.Mech.E.*, Vol. 154, page 376, 1946.

[4] Mansfield, W. P., and Cornish, A. H., " Methods for Obtaining Pressure Diagrams," B.I.C.E.R.A. Report No. 51/S., 1951.

[5] Hempson, J. G., and Roach, W. J., " A Modified Farnboro Electric Indicator," B.S.R.A. Report No. 92, 1952.

Recent Developments in Sewage Plant and Control at Mogden

Mogden sewage purification works in West Middlesex was probably the last word in contemporary practice when it was opened in 1935. Since that time, however, further mechanisation has taken place, and experience has been gained with novel and interesting plant. This work was discussed at the Public Works and Municipal Services Congress last Friday in the paper "Recent Middlesex Developments in Mechanisation and Automation of Sewage Plant Operation" by Mr. C. B. Townend, C.B.E., M.I.C.E., extracts from which are given here.*

IN a period when electronics have become accepted as a standard tool for so many purposes, it is interesting to note that the first electronically operated metering equipment in the world was installed in this country on a sewage works and has been in operation now for nearly twenty-five years. Equally for the same length of time, a meter has been in full charge of the operation of a penstock controlling the main flow of sewage to treatment plant—a device incorporating the basic elements of automation.

In all such ways has it been possible for modern sewage plant to be operated by remarkably few men in relation to the large amount of work to be done. A large-scale works in Britain to-day may require for its operation and maintenance only one worker per £40,000 to £50,000 of capital expenditure, a lower requirement than in the most highly mechanised plants of modern industry. These considerable achievements are all the more meritorious because most of the basic progress in labour saving was made at a time of heavy unemployment when there was no immediate incentive for such advances.

Desludging Machine for Secondary Tanks

At the West Middlesex works the battery of four secondary sedimentation tanks has now been equipped with four machines of light alloy supplied by Templewood Hawksley, Ltd. Each machine is 154ft long supported at the two ends and on the centre wall dividing the two bays. The main drive is by electric motor through a fluid coupling to rack rails on all three walls. The scraper is of the usual hinged-arm type with a blade of minimum height to avoid turbulence. All shafting is carried in resin-impregnated fabric bushes requiring no greasing.

The weight of the new double-span machine is about 7 tons as compared with about 20 tons for the old single-span machine; the power has been reduced from 5 h.p. for the old machine to 2 h.p. operating the double-span of the new machine.

The sequence of operational movements is capable of various arrangements ; at present the machine commences by sweeping one-third of the 210ft floor-length into the hoppers, then two-thirds and then three-thirds in succession, at the end of which a period of rest up to four hours can be allowed ; the whole of these movements including the raising or lowering of the scraper at the ends of travel are entirely automatic.

Final Separating Tanks

Following the activated sludge plant are fifty-two final separating tanks of upward flow type, each 60ft diameter with vertical side-walls to a depth of 8ft and conical floors sloping at 30 deg. to a total water depth of 25ft ; the total capacity is 13 million gallons.

The tanks were designed to separate activated sludge and return it into the zone of oxygen supply in aerated channels as quickly as possible. To this end, a rate of return from the bottom of 50 per cent of that of the sewage flow was allowed for, and with the same requirement in mind, the ring-type of machine was originated for this plant with the object of providing continuous scraping of the floor by eight radial blades.

From the earliest days of operation, the tanks were very successful ; for a continuous period of some fourteen years, the average figure for suspended solids in the effluent (from hourly samples) was 7 p.p.m., and in recent years, monthly averages as low as 3 p.p.m. have sometimes been obtained.

To which feature of the tank could be ascribed the credit for these results—whether general design or the ring-type machine—was always a matter of some conjecture. During the war, however, individual machines were put out of action for limited periods on a number of occasions by shell splinters, incendiary bombs and other objects, with apparently little or no effect on tank performance. In later years this experience was confirmed when odd machines were out of action for longer periods awaiting overdue maintenance. The conclusion was then reached that the design of this particular tank was the main factor in its performance, and that while it would be unwise to completely dispense with the machine, an alternative type of the greatest possible simplicity, designed only to ensure that no solids were allowed to contaminate the floor, should be adequate.

After much experimental work, the "Middlesex" type was evolved and constructed in the Mogden workshops. It consists of a tubular boom of aluminium alloy, 7in in diameter and 30ft long, rotating round one end connected to a central pivot, the outer end being fixed to a carriage travelling on the circular weir of the tank. The side wall is scraped below water by a hinged rubber blade mounted on an angle supported by the travelling carriage ; to the bottom of the angle is fixed one end of a scraping chain formed of 2¾in by 1¼in links which is trailed along the sloping floor and extends in a curve of its own formation to the centre at the bottom.

The drive on the outer carriage is by electric motor of ½ h.p. at 1450 r.p.m. through double worm reduction gear and "Duplex" chain to rubber tyred wheels at 1 r.p.m. ; the speed of travel along the weir is 3ft per minute giving about one rotation of the machine per hour. Brushes are fitted to provide continuous cleaning of the weir and the effluent channel. At the centre of the tank, the pivot is mounted on the top of the tank inlet pipe ; a fixed vertical shaft carries a rotating boss fitted with a hinged casting to give a flexible support for the boom. Current is supplied by cable in conduit up the centre of the tank via horizontal slip rings mounted on the fixed shaft and thence by cable housed in the boom to the driving motor.

One machine of this type has been in operation now for four years and another for 2½ years with excellent performance ; the tanks have been emptied on a number of occasions when the floors and side walls have been found perfectly clean. Small points of difficulty in securing adequate traction grip on the weir have been overcome.

Twelve machines are at present being made in the Mogden shops and erected on new tanks recently constructed as part of the west-side extensions. These machines will cost less than one-fifth of that of ring-type machines, and will effect a considerable reduction in maintenance cost, particularly of painting. The weight of the new machine is about 4 cwt as compared with about 4 tons for the ring-type machine. The existing fifty-two machines will be gradually replaced by the new type as wearing strips and blades become due for renewal.

Primary Sedimentation Tanks

For the west-side extensions of Mogden Works now under construction to bring the population capacity of the plant up to 1,500,000, four single-stage primary sedimentation tanks have been provided to take a maximum flow of 15 m.g.d. each. These tanks are 140ft in diameter with constant velocity radial flow, for which a floor of hyperbolic profile is required ; this floor has an increasingly steep angle of slope towards a deep central well.

Each tank is provided with a simple desludging machine of the rotating bridge type supplied by W. E. Farrer, Ltd., to the special requirements of this tank. The bridge of light alloy is 70ft long supported in the centre of a "T" shaped turntable running on three wheels on a circular track mounted on an inlet baffle wall structure. The outer end of the bridge is driven by a motor of 2 h.p. mounted on a carriage running on rubber tyred wheels on a circular concrete runway forming part of the outer wall. The weight of the machine is 3¼ tons.

The scraper blade is in one continuous length, its horizontal curved shape being designed to bring the sludge from the circumference to the centre in about one revolution ; it is also curved in a vertical plane to follow the shape of the floor. The hinged trailing arms are arranged in three pairs, each pair being braced by angle ties to prevent side movement of the blade down the slope towards the centre ; flexible overlapping of blade lengths allow for small variations in floor construction. In the expectation that sludge deposits will never exceed very small dimensions, the blade height at the periphery is only 4in increasing to 9in in the centre.

The peripheral speed of travel is 4ft per minute allowing one revolution in about 110 minutes. The machine is intended to work continuously so that on any particular square foot of floor area, undisturbed quiescent settlement for about two hours is provided between successive sweepings ; this should be an excellent arrangement.

The existing first stage sedimentation tanks are radial flow circular tanks of 95ft diameter equipped with rotating-bridge type machines spanning the full diameter with no central support. These have given good service but are very heavy, and although self-centring

* Chief Engineer, Midland County Main Drainage Department

they cause excessive wear and tear to rails and walls, and may occasionally jump the track entirely. The trailing blades are of the echelon type which require a large number of revolutions of the bridge to bring sludge from periphery to centre.

The small central channels to which sludge was delivered were replaced some years ago by cylindrical hoppers 20ft deep with greatly improved results.

A programme has now been commenced to replace the whole of the desludging equipment by light alloy machines similar to those being installed in the new tanks described in the preceding section. One machine is now being installed by W. E. Farrer, Ltd., as a prototype for a period of prolonged operation before proceeding with the remainder. The weight of the new machine is about 2½ tons as compared with 15 tons of the old machine ; the power has been reduced from 6 h.p. to 1½ h.p.

Lifting Sludge from Drying Bed

It was established that the open-air drying bed is still the cheapest method of dealing with sludge in Middlesex conditions, but nevertheless the drying bed was capable of great improvement by mechanisation of sludge removal which could result in more efficient drying with lower costs of capital construction works and of operation. The principal initial decisions were :

(*a*) the machine should be of a travelling bridge type running on rails supported by the side walls of a bed 60ft wide ;

(*b*) the sludge should be run on to a liquid depth of about 6in giving a dried cake thickness of 1¼in to 2in ; for this reason, the side walls should not be carried up more than about 9in above the medium ;

(*c*) the lifting of the sludge should be in the direction of the length of the bed and across the full width of the span simultaneously ; the sludge as continuously removed should be elevated and delivered on to a cross conveyor for discharge at one side of the bed ;

(*d*) the output of the machine should be 1 cubic yard per minute giving a required forward speed of about 3ft per minute ; if working without interruption, this output would produce about 500 cubic yards per day;

(*e*) to obtain the minimum loss of time in transferring the machine from one bed to another, the beds should be as long as possible ; at Perry Oaks (the sludge disposal works associated in the Mogden) a continuous bed length of 600 yards is possible and at the Rammey Marsh disposal site for East Middlesex, the length could be even more if necessary ; with this length, a full day's work would be available for the machine without stopping ;

(*f*) the main bridge and as much of the structure as possible should be made of aluminium alloy in order to reduce weight to a minimum with a cheapening of rails and supporting walls where most of the ultimate expenditure would be needed ;

(*g*) that a prototype machine should be built of the full-scale final dimensions except that the span should be of 20ft only, to be tried out under actual working conditions on a specially constructed experimental bed of 300ft long.

To this end, in 1957 an arrangement was made with Templewood Hawksley, Ltd., for the development of the prototype machine as a joint effort of collaboration between the Department's staff and the company. The machine was delivered during the summer of 1958, but owing to the exceptionally adverse weather conditions of that year, the amount of operational experience gained was limited. During the better conditions of 1959 very considerable progress was made, and a number of important modifications were made which by the end of that summer resulted in satisfactory operation.

The 20ft machine is designed to cover all the main outline requirements listed above. The dried sludge is eased off the medium by tines which move forward with the machine at the correct level ; this level is adjusted to suit the particular bed by power-operated control. The sludge is fed to the elevator by a rotating paddle ; elevation is by flight conveyor fitted with angle iron slats discharging at the top to a belt conveyor for delivering sludge to one side of the machine ; the elevator backplate is provided with slots for scraping off excess sand from the underside of the sludge cake allowing it to fall back on the bed.

The power supply is diesel-electric, the engine being located on the top of the bridge ; current is fed to four independent motors driving the various shafts individually. The total power requirements vary from 12 h.p. to 20 h.p. according to the conditions of the sludge. The original main drive by friction on normal track rails was not satisfactory and was replaced by a type of rack drive.

In other details, it has been found that the length of the tines, the relative speeds and power applied to the various movements, the shape of the paddle teeth, and other items must all be properly provided before the machine will work satisfactorily as a unit. A good performance with soft sludge in 1958 proved useless with the brick-hard cakes of 1959, but sludges over the entire range from very wet and medium to very dry, and from 1½in to 2½in thick, have now been tackled with equal facility.

The state of progress was sufficiently advanced in the autumn of 1959 for the decision to be made to go ahead with a 60ft machine. In the meantime further proposals have been adopted which go far beyond the original objective of mechanisation of lifting —to the automatic conveyance of dried sludge to the marketing bay, storage, or tip site, by continuous equipment replacing the present system of haulage in tip-wagons by diesel loco, and largely eliminating the use of labour at any point.

Mechanised Sampling

The need for some method of taking samples of sewage and effluent at various points of works operation by mechanical means has long been pressing. In recent years, several machines have been devised for this purpose including the " Middlesex " type, a few notes on which may be of interest.

The machine is designed for taking hourly samples during twenty-four hours, with variable timing if required. A self-priming pump (which can lift 20ft) controlled by time-switch delivers the sample from a suitable point in the main liquid into a receiving tank, this having a capacity greater than that of the suction and delivery pipe. When the tank is full, a float brings the delivery pipe exactly opposite a spout delivering into a hinged measuring trough ; when this tips, the sample is discharged through a rotating funnel into the appropriate bottle. The funnel discharge moves at the end of each hour to the next bottle, the movement being by motor controlled by time-switch. Any surplus liquid is handled by the reception tank which is emptied automatically at the end of each sampling operation.

Arrangements are made to prevent contamination of one sample by the previous sample, to vary the amount of the sample to suit the size of bottle, to prevent spillage from bottles, and to put the operation out of action at the end of twenty-four samples until these have been cleared and the machine reset by hand.

Apart from the saving of labour, the great advantage of mechanisation is the elimination of the human element in ensuring proper samples. The advantage of taking individual samples each hour is the ability to detect unusual discharges which have taken place without warning particularly during the night.

Remote Control

Power-operated control of valves and penstocks is desirable (*a*) where the operation is a daily or frequent requirement needing considerable manual effort, (*b*) where important operations of an emergency type must be carried out, such as in times of heavy rain, particularly when they are likely to occur at night with no men available, or (*c*) where operation at a considerable distance from the control point is necessary. These cases may all be classified under the general heading of " remote control."

For such a purpose, both electric and hydraulic equipment has been available for many years. Examples of both types were installed on the original Mogden plant twenty-five years ago, but their relatively high cost has in general limited their application to the more important cases.

With the growth of automation techniques in the chemical and oil refining industries, there has been a considerable development of remote control appliances with much lower costs which is likely to open up new applications in sewage works operation.

For the control of stormwater tanks and main adjoining channels, fifty-eight penstocks are installed including six main penstocks (8ft by 7ft) on stormwater culverts, forty-eight inlet penstocks (5ft 6in by 2ft 6in) in eight stormwater tanks, and four effluent shaft penstocks (5ft by 9ft). The whole of these gates were installed for electrical operation by independent motors from push-button starters housed in adjacent cabinets. Their operation involved a shift man walking for distances up to ½ mile from the main sewage pumping station, very often during the night in heavy rain at a time when he could be least spared.

In 1957, it was decided to link the whole installation by four seventy-five-core plastics insulated cables to a remote control panel located in the main meter room of the pumping station.

The push-button control has been repeated, lamps being provided to indicate when each gate is in the open or closed position. The panel has a penstock diagram the pattern of which is matched by the position of the push buttons.

The stormwater tanks are brought into operation one by one by the shift charge engineer in accordance with the total flow arriving at the works. This is done with an efficiency in adverse conditions never previously achieved and with a considerable saving of physical effort.

It is to be noted that it would be a comparatively simple step to link up the flow meter with the panel to provide complete automation. If this could cut out an operator it would be done, but as the operator must be present in any case, there would be no point in doing this.

For the removal of sludge from hoppers of the two stages of sedimentation tanks, forty sluice valves have to be operated daily, some of them on several occasions. The sludge is drawn off via inspection chambers which operation requires considerable labour and is not entirely free from odour.

For some years past, it has been the objective to replace this system by remote control in conjunction with some other form of sludge detection.

The former methods of electrical operation of valves were expensive. In 1957 a pneumatic system became available at only about one-half of the cost, employing a small air motor in the form of a plunger-operated unit working by means of a ratchet wheel mounted on the valve spindle ; two motors are fitted to each valve, one for opening and the other for closing. The unit can be fitted to any standard valve and to any headstock pillar. The presence of the unit does not prevent hand operation. The air is transmitted at a pressure of about 80 lb per square inch in small-bore plastic pipes, the smallest being ¼in bore ; the air consumption is very small.

This system was fitted in the first case to one half of the valves operating from a control board in one of the two sludge pumping stations. In operation some troubles have been met with maintaining air-tight pipe joints and from a tendency of valves to chatter when fully open or closed ; measures are being taken to remedy these but operation is not yet entirely satisfactory.

More recently, an electrical system has become available on a similarly competitive basis and this is being applied to the other half of the valves to operate from a control board in the second of the sludge pumping stations. Each unit will incorporate a direct motor-driven gear having open-closed limit switches, and excess torque switch to prevent damage to the motor from unexpected obstruction during operation. Again the unit can be fitted to any standard valve and will allow hand control.

Sludge Density Measurement

In general, sewage works plant for many years has been reasonably well equipped with instruments of various kinds for measuring flows, pressures, temperatures, levels, &c., of sewage, effluent, sludge, compressed air, gas, and so on. More recently considerable progress has been made in recording pH, dissolved oxygen and so on. One important gap in this field has been the means to measure the density of sludge at the bottom of a tank or other point. During the period of design of Mogden Works in the early 1930s, the existence of such a development could have led to better operational arrangements and the matter was actively pursued at that time without success. On many occasions during the intervening years, the author has mentioned the question to instrument makers and others who in general thought it should be possible but never succeeded in doing it.

During the past five years, however, the department's own staff have evolved an instrument which has proved very satisfactory for Mogden conditions, and appears to have promise for general application elsewhere.

The main problem arises because of the extremely small differences between the density of sludge and that of water. The weight of a given quantity of settled sludge is usually not more than 1·03 times that of water and the normal instruments available for determining changes in density are not suitable for this degree of sensitivity.

Desludging Sedimentation Tanks Automatically

The development of machines for the continuous scraping of sludge from tank floors into hoppers has been described. By the use of this instrument for the measurement of density of the sludge in those hoppers, it is possible to produce an electrical signal automatically which will open the appropriate discharge valves by remote control, and operate a pump to deliver the sludge to digestion tanks without manual intervention.

The control unit which has been developed at Mogden for this purpose consists of two G.T.I.C. relay valves—one for primary tanks and the other for secondary tanks ; this duplication is necessary because of the difference in the densities of the two sludges. The valves are operated on 240V a.c.

The control of the circuit is by the valve-grid. Anode-cathode discharge is withheld by the application of a negative grid bias ; once the bias is reduced below the critical value, anode-cathode discharge occurs and the grid would then normally have no power to control the discharge. The detector, however, is a.c. operated and as the anode circuit falls to zero during every cycle, the grid controls instantly.

Nevertheless, it is not possible to control the equipment directly through the grid circuit because when the resistance of the liquor in the hopper decreases, the grid bias would increase and so prevent any anode-cathode discharge at all. However, by using the detector as a diversionary circuit, the normal characteristics of the relay are reversed, and where an increase in voltage would prevent discharge, the opposite effect is obtained. Extremely good control is thus effected and the life of the valve is extended.

In order to avoid danger from high voltage in contact with the tank liquor, low tension current is used in the detector by transforming to 12V.

Incorporated in the equipment is a test circuit with a hand-setting device in order that the operator can select the quality of sludge to be removed from the hopper and predetermine the point at which the control unit shall operate.

The control unit operates by means of a rotating arm driven by a time-motor and moving over segmented contacts which connect the detector elements in the hoppers to the relay circuits in any desired sequence. Thus each hopper will be visited in turn, and if the predetermined quality of sludge is present, an electrical circuit will be made to the relays which bring into action the operation of hopper valves and electrically driven pumps. As soon as the sludge is cleared and the density falls to a second predetermined point, pumping will be discontinued from that hopper and the valve closed.

As mentioned previously, different limits of density range are used for starting and stopping the pumping of sludge in secondary hoppers than in primary because of the thinner character of the sludge produced in the former. As the result of prolonged experience, it has been found desirable to vary the limits also in the primary stage at certain times in the year when sludge is inclined to be thinner. To carry this out automatically, an improvement has been made by operating the equipment on the basis of the differential reading between that of the incoming sewage and of the settled sludge. For this method of working, an additional probe is needed in the incoming liquor.

Many other refinements are fitted to the equipment to prevent hunting, to deal with the problem of gassing interfering with the priming of pumps, to indicate the valve positions, &c.

In every way the equipment has satisfactorily fulfilled all the requirements originally laid down for the accurate detection of sludge and its removal entirely under automatic control.

Operation on full automation was established some two years ago, but the development of this part of the equipment has outrun the final completion of the continuous desludging machines and the work on conversion of valves to remote control, with the result that it may yet be some months before the plant can be handed over for continuous day and night operation on automation.

When the plant is operating as planned, there will be a reduction of labour on machines, valve operation and pumping, of some four men working a seven-day week plus some overtime—equivalent to say, six men on normal day work.

It is expected also that desludging operations controlled by density measurement will result in a reduction in the total volume of sludge production thus ensuring more efficient use of digestion capacity. This could easily represent a considerable saving in capital expenditure.

The system is not complicated or expensive and does not contain any dangerous working parts. Most plants could be adapted without much difficulty ; maintenance should be within the scope of the average maintenance engineer. The original detection and control apparatus (not including pump or valve control) for the existing east-side plant treating about 50 m.g.d. of the total flow of 75 m.g.d. was produced in the Mogden workshops at a cost of a few hundred pounds. This equipment occupies a space of about 2ft by 2ft by 4ft high.

Desludging Stormwater Tanks

Two of the eight stormwater tanks at Mogden are brought into operation much more frequently than the remainder and these have now been equipped with continuous desludging machines. Up to the present time, the removal of sludge from these tanks has only been possible by working overtime in the evening when the day's normal sludging of sedimentation tanks has been finished ; with labour shortage this has often had to be delayed for prolonged periods resulting in septic conditions. When the main programme of automation has been completed, it is intended to extend the system to serve these two tanks so that desludging can come into operation automatically whenever the tanks are filled. In the case of a night storm, the manager will then arrive in the morning to find the stormwater sludge already pumped away to the digestion tanks.

Sludge Digestion Operation

The Mogden installation of digestion plant now includes sixteen tanks of nearly 1,000,000 gallons each. The daily operations of withdrawal to Perry Oaks and recharging with raw sludge will be increased by other developments including recirculation for external heating and gas recirculation for mixing, all requiring a considerable amount of manual effort in valve operation over a three shift system.

Consideration is being given to the application of automation procedure to all of these operations, the controls being based on measurement of volume, temperature, and level as the case may be.

LETTERS AND LITERATURE

Letters to the Editor

THE BRITISH STEAM LOCOMOTIVE SINCE 1900

SIR,—Mr. A. E. Durrant's statements (page 800) about this article or its author are all, without exception, untruths. The irrelevance of his foreign scraps makes their inaccuracies unimportant. His numerous surmises are significant only in their consistency with his demonstration, in his third paragraph, that his lack of understanding of basic elements of the British steam locomotive is such as to make further discussion unprofitable.

W. A. TUPLIN

Sheffield,
November 19.

ROAD ACCIDENTS

SIR,—May I take up the point made by "Callipides" ("Letters to the Editor" page 631, THE ENGINEER, October 14) that nearly a quarter of the adult casualties in pedestrian accidents were due to starting to cross the road when masked by stationary vehicles from the view of oncoming traffic.

One might point out that the banning of stationary vehicles on arterial roads would not only reduce the number of pedestrian accidents, but would also reduce accidents between vehicles which occur as a result of two or three lanes of traffic suddenly being reduced to a single lane.

The banning of parking on arterial roads is long overdue, and would surely present little difficulty in enforcement.

DAVID WHALEY,
A.F.R.Ae.S., F.C.I.P.A.

Gerrards Cross,
November 15, 1960.

ANGLE OF APPROACH INDICATORS

SIR,—In your issue of October 28, 1960 you published a summary of British Patent Specification No. 848,583, entitled "Angle of Approach Indicators." The invention covered by this patent bears, at first sight, a close resemblance to the V.G.P.I. (Visual Glide Path Indicator) system, recently introduced, and now being adopted, or about to be adopted, by most of the member countries of the International Civil Aviation Organisation. In fact, the invention referred to is one of several made during the course of development work on certain problems associated with carrier-borne aircraft, and has no direct connection with the V.G.P.I. system, which was invented by the R.A.E., Farnborough.

As this company is manufacturing the V.G.P.I. equipment under licence, we would like to make it quite clear that the Patent Specification reviewed by you has no connection with this very important new British lighting aid recently introduced for Civil Aviation.

We feel this step is necessary because some confusion has already become evident among consultants specialising in aviation lighting, and it may be thought that the G.E.C. patent competes with the R.A.E. patent. This is not so.

J. C. ADAMS
Exterior Lighting Section,
Lighting Division
The General Electric Company, Ltd.,
Magnet House, Kingsway,
London, W.C.2.
November 15, 1960.

THOUSANDS OF MILLIONS TO BE SAVED?

SIR,—It seems that, since 1958, you have acquired a new generation of readers personified in Mr. R. G. de Bray who, in your issue of November 18, resurrected that very piece of railway propaganda (about a train being worked by only three men, or two) which you selected for exposure in your leading article entitled "Twilight or New Dawn for Railways?" on December 12, 1958. A week later, Mr. de Bray should also know, in "Clear Thought about Railways," you had occasion to deplore that the Minister of Transport had "allowed himself to be taken in" by the same fable: he had meanwhile delivered himself of it in Parliament. Unhappily, in spite of your efforts, it remains one of the most popular legends in railway mythology. But the bulk of your readers will feel that they have already graduated in the manpower sector of the argument for railway conversion, so it will be more profitable to move on and consider the traffic engineering basis for the proposed utilisation of double and single-track railbeds for three-lane or two-lane single-carriageway motorways, upon which subject both yourself and Mr. de Bray expressed doubts.

The basis is extant already, virtually, in Switzerland. The Swiss motorway programme, for the non-Alpine part of the country, comprises 360 miles of Class I Motorways (dual two-lane carriageways) and 350 miles of Class II motorways which are to be of single-carriageway construction, three-lane or two-lane in width. The capacity of these roads is reckoned to be 8000 passenger-car-units per hour for Class I; 3000 passenger-car-units per hour for Class II three-lane, and 2000 passenger-car-units per hour for Class II two-lane. The Commission that arrived at this solution studied their subject for five years; broadly, they matched the new motorways against traffic volumes two and a half times those of 1955; their reasoning is given in a six-volume report published in 1959.*

Through railway conversion Britain's double and single-track railbeds will become almost identical with Switzerland's Class II motorways, varying between three-lane and two-lane in width; and—to come to the crux of the matter—it is hardly possible to pinpoint one solitary stretch of double or single-track in this country where, after the entire system has been converted, the traffic flow might exceed 2000 passenger-car-units per hour. To widen these railbeds into four-lane roads would be a totally unjustifiable expense. This is not a matter to which limitless research has been devoted, and possibly someone will unearth some piece of line that might become overloaded; the answer would be to widen that particular short stretch; but to find it could be a complete winter pastime, notably for traffic engineers, who would duly apportion the gross traffic of the area under examination between, (*a*) the line in question; (*b*) the other railway lines, similarly converted, which will never lie very far away, so profuse is Britain's railway system; and (*c*) the ordinary public streets, roads and motorways, which—it is sometimes necessary to remind the antagonists of conversion—would still exist.

Thus as a result of railway conversion Britain would acquire a new network of motorways varying in width, and in classification, according to their patronage. If this basis is faulty the Swiss would surely be interested to know, for it is theirs also, and upon it they propose building some £311 million worth of roads—for a population about one-tenth the size of ours. Incidentally, at current prices (and pending the receipt of tenders for the pilot conversion you have bravely advocated), it can be taken that a similar sum would cover the paving, kerbing and lighting of about 10,000 miles of Britain's railways; the title of your article could safely have been printed, without the question mark, "Thousands of Millions to be Saved."

T. I. LLOYD

Guildford,
November 19, 1960.

MODERNISATION: ROAD, RAIL OR BOTH

SIR,—There is one point which is frequently overlooked when comparisons are made between the cost of railway modernisation and road construction and your leading article in THE ENGINEER for November 4, 1960, appears to fall into this error.

You refer to the speech made by the Joint Parliamentary Secretary to the Ministry of Transport in the course of which he contrasted the cost of the projected electrification of the London Midland main line with that of the construction of M1.

This is an entirely misleading comparison inasmuch as the cost of electrification includes not only civil engineering work in the shape of re-alignment, relaying and improving of tracks, the alternation to structures and bridges, installation of the overhead and electrical distribution system and signalling but also the provision of new locomotives and rolling stock, and the means of housing and maintaining these, &c.

The construction of M1 represents purely the civil engineering side of the undertaking plus a small amount of "signalling," but nothing for the cost of the vehicles using it or

* *Die Planung des Schweizerischen Nationalstrassennetzes*, Eidgenossische Drucksachen-und-Materialzentrale, Bern, 1959.

the garage, parking, loading and unloading, and maintenance facilities required for them.

Any comparison of railway expenditure with that of the roads should in equity cover the same ground in each case. If the cost of new vehicles, which after all is a cost to the country, were added to the annual sum spent on roads, any comparison with railway expenditure would make the latter appear quite modest.

R. G. JARVIS,
B.Sc.(Eng.), A.M.I.Mech.E.

Burgess Hill,
Sussex,
November 17, 1960.

[We quoted Mr. Hay, the Joint Parliamentary Secretary to the Ministry, as saying that the projected electrification of the London Midland Main Line will cost about £160 million or eight times as much as the cost of constructing M1. His comparison, as our correspondent points out, is crude. Any error is not ours.—Ed. THE E.]

RAILWAY CHAOS

SIR,—Your comment "Electrifying the Hard Way," THE ENGINEER, November 4, high-lights but one aspect of British Railways' overall chaotic policy which is resulting in enormous capital expenditure for insignificant improvements in rail services.

The opinions expressed on the economies of 25kV. a.c. *v.* 1500V d.c. electrification have long been in the minds of many engineers. As both Manchester London Road and Liverpool Street already had 1500V d.c. systems in existence, it would appear to be an obvious course to extend those systems. It is interesting to reflect upon Southern Railway electrification during the late 1930s, particularly the longer routes such as the Reading and Portsmouth lines. There was certainly none of the disastrous upheaval now being experienced during electrification works.

However 25kV a.c. is now established and must presumably be the standard, but it is reasonable to question the necessity for wholesale station rebuilding, resignalling, civil works, other than those required for clearances &c. Track alignment without modification was suitable for pre-war schedules which do not appear markedly inferior to those predicted for electric traction. Elimination of steam traction automatically improves stations ; the use of paint and minor alterations would meet reasonable standards. Such grandiose schemes as rebuilding at Leeds (£4,500,000) are quite unnecessary under the present difficult circumstances.

No organisation can afford such uncoordinated chaotic projects as the lifting of overbridges on the East Coast line when electrification is shelved indefinitely, the purchase of "Deltic" locomotives to operate a service which is being performed satisfactorily by some of the best steam locomotives ever built and also without any clear idea of the schedules to be run, double-heading by apparently under-powered diesel locomotives to schedules no better than pre-war on the Midland division.

The French Railways are in receipt of a subsidy, but they can show some very positive results from their modernisation programme. In this country we only hear the oft repeated promise that modernisation will put all to rights. In actual fact there is little more than a huge expenditure to be seen.

The situation indicates that there is something sadly wrong with British Railways' policy ; fanciful schemes such as "Hover Trains" are not conducive to a sober background. There is much sensible and constructive criticism from informed persons outside the industry, but it just does not reach receptive ears.

M. W. BURNBY

Sheffield,
November 16, 1960.

Book Reviews

Change at Crewe. London Midland Region, British Railways, Euston House, London, N.W.1. Price 5s.

ALTHOUGH written in a popular style and basing its appeal largely on illustrations—several of them in colour—this publication forms a useful source of reference to the varied engineering work involved in electrifying the main line from Crewe to Manchester on the 25kV, single-phase, a.c. system. Whole-page diagrams show the location of feeder stations and track-sectioning cabins, and of the many improvements undertaken at stations and in the track layout to modernise facilities and relieve speed restrictions, so that the new form of traction could be introduced in a setting enabling it to exercise the maximum attraction on potential users of the railway. There are also two annotated diagrams showing details of the overhead line construction, with enlarged inset sketches of some of the features which are difficult to distinguish for the interested observer at ground level. A glossary of terms includes many associated with overhead wiring practice. There is less detail on the electrical equipment of the motive power for the line, and to give only eight lines to the locomotives but twenty-six to the multiple-unit trains is curious. It is also a pity that the fact that the multiple-unit sets saw the first large-scale application of semiconductor traction rectifiers is not only ignored but actually obscured by the statement that rectification is mercury-arc. In contrast, signalling and telecommunications receive five pages of text and pictures, including some detail of track circuit lengths and forms of feed.

Much has been published in recent months on 25kV traction in general and the Crewe–Manchester line in particular. With the reservation that "Change at Crewe" has shortcomings on the technical side, it can be recommended as an attractive souvenir of the first step in an undertaking which seems destined to become a subject of controversy.

Mechanics of Materials. By ARCHIE HIGDON, EDWARD H. OHLSEN, WILLIAM B. STILES. Publishers : John Wiley and Sons, Inc., New York. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 62s.

THIS book offers a good introduction to the subjects of stress, strain, bending, torsion, combined loading, dynamic loading, strength of columns and strength of riveted and welded connections. It makes early reference to the subject of stress concentration and to design on the basis of elastoplastic behaviour of steel. A notable feature of the book is the large number of appropriate problems, although their accompanying stylised drawings, illustrating very clearly what the problem is, may perhaps be criticised as being unrepresentative of conditions in practical design.

In connection with the bending of beams the book mentions that the straight-line distribution of direct stress across a transverse section is ascribed to Coulomb who announced it in 1773 although it had in fact been pointed out by Parent some sixty years earlier. Nevertheless the book refers to "Coulomb's Theory" and no doubt the prior claim of Parent will continue to be ignored.

The book refers to "second moment of area" but adds that it is commonly called "moment of inertia" and seems to resign itself to that regrettable fact. The authors possibly think that if general adoption of the correct term should demand continued advocacy for anything like sixty years, no reformer is likely to see any satisfactory result of his efforts and so they are not worthwhile. Conventional presentation of the elementary theorems in this group of subjects is handled lightly and the numerous shaded diagrams will no doubt make the book appear less formidable to the newcomer than might otherwise be the case.

Obituary

R. M. ATKINSON

WE regret to have to record the death of Mr. R. M. Atkinson, which occurred on November 12 in his seventy-first year.

Robert Morton Atkinson was educated at Oundle School and Sheffield University, after which he became an engineering pupil with Vickers, Ltd. From 1912 to 1916 he was assistant manager at the drop forge of Vickers Ltd., being then seconded to the Ministry of Munitions as Director of Forgings and Castings and later to the Air Ministry as Director of Materials and Supply (Rolls-Royce Engine Branch). From 1919 to 1924 he was deputy manager of the Railways Department of Vickers-Armstrongs, Ltd., after which he undertook extensive travelling for Vickers, Ltd., and associated companies, in connection with overseas sales policy.

After some thirty years with the Vickers Organisation, he left them in 1938 to join the Sulzer Organisation as managing director of Sulzer Brothers (London), Ltd., which position he held until his appointment as chairman of the Company in June this year. In 1952 he joined the Board of Richardsons, Westgarth and Co., Ltd., and their subsidiary company, George Clark (Sunderland), Ltd., which appointments he retained until his death.

Robert Atkinson was a man of many parts. In addition to his membership of the Institution of Mechanical Engineers and the Institute of Marine Engineers, and other professional bodies, he maintained a keen interest in the affairs of Oundle School and served on the School Memorial Trust.

Books Received

Spectrochemical Abstracts. Vol. VI. 1954-55. By Ernest H. S. van Someren and F. Lachman. Hilger and Watts, Ltd., 98, St. Pancras Way, London, N.W.1. Price 25s.

Nuclear Engineering Monographs. No. X. *Approaches to Thermonuclear Power.* By R. F. Saxe. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 12s. 6d.

Iron and Steel : Annual Statistics, 1959, for the United Kingdom. Published jointly by the Iron and Steel Board and the British Iron and Steel Federation, 7, Park Lane, London, W.1. Price 7s. 6d.

Overseas Newspapers and Periodicals Guide Book. Seventh Edition. By H. R. Vaughan. Publishing and Distribution Company, Ltd., Mitre House, 177, Regent Street, London, W.1. Price 30s.

Industrial Value of D.S.I.R. Research—No. II*

POLLUTION FROM ELECTROPLATING WASTES AND FROM OIL—PART I

At the Water Pollution Research Laboratory at Stevenage a long sustained effort has been exerted to discover methods of treating various industrial wastes so that effluents will not pollute streams or rivers into which they are discharged or alternatively will be accepted by a local authority into the public sewers for treatment at a sewage works. Problems for which acceptable solutions have been found include treatment of electroplating wastes, and treatment of oily waste waters from engineering factories. The work of the Laboratory is first summarised. In the latter part of the article the views and comments of a number of firms are reported and descriptions given of plants in service.

ELECTROPLATING WASTES

SOME thirty years ago the problem of treating wastes containing cyanides was proving decidedly intractable to the relatively few people who bothered very much about the disposal of noxious effluents. The attention of Dr. Southgate, the present director of the Water Pollution Research Laboratory, was drawn to this problem through certain work he carried out for the River Tees Survey Committee. Dr. Southgate was called in to investigate the causes of the toxicity of the waters of the polluted Tees estuary to the run of sea trout and salmon which still at that time went up that river to spawn, and particularly to the smolts moving down to the sea. At the time it was not known to what the toxicity was mainly due; suggestions included lack of dissolved oxygen and the presence of tar acids and tar bases. Dr. Southgate discovered the influence of cyanides and in a paper entitled "Toxicity of Mixtures of Poisons," published in 1932[1] he recorded some of the results of his work. The relevance of those researches in the present context arises from the fact that cyanide is a constituent of some electroplating wastes. Also, it should be noted that the attention of Dr. Southgate was drawn by this work (and by other work he had undertaken) to the use of fish as indicators of the degree of pollution present in a sample of water, and of the satisfactory or unsatisfactory nature of an effluent. In the following year that work was followed up by studies of "The Effect of Cyanides on the Gill Colour of Fish,"[2] carried out in conjunction with Bassindale and Pentelow. Though scarcely relevant here it is worth noting that one of the findings of the paper was that cyanide poisoning causes a marked and characteristic brightening of the colour of the gills of fish.

Later in the same year Dr. Southgate read a paper before the Northern Section of the Coke Oven Managers' Association.[3] It was entitled "An Investigation of the Toxicity of the Coke Oven Effluents Discharged into the Estuary of the River Tees," and one of its conclusions was that the factor mainly responsible for the death of salmon and sea trout smolts in the Tees estuary in the previous two years was the cyanide discharged into it as a constituent of effluents of gas coolers of coke oven installations. It records that methods of treating the effluent were investigated to eliminate or at least to reduce the amount of cyanide present. One method depended on the interaction of ferrous chloride with cyanide to form ferro-cyanide, a relatively non-toxic substance, the idea being that the chloride was available locally as spent pickle liquor from the cleaning of steel in hydrochloric acid for galvanising plants; another upon spraying the heated effluent into the air as a fine mist. Neither method seems to have been adopted, although each was tried out industrially. There was, indeed, little incentive for industry to adopt them. For until the recent passing of the Clean Rivers (Estuaries and Tidal Waters) Act which came into operation on September 29 this year, unless the Minister of Housing and Local Government laid down a ruling in the opposite sense, the tidal waters of an estuary were not legally protected against pollution in any degree. It is, however, very well worth putting on record, and to the credit of industry, that claims were made for a new plant built on the Tees estuary in about 1936, that the discharge of cyanide had been avoided.[12] Sad to relate the matter was of little more than academic interest. For at about the same time pollution of the estuary became so bad that the run of sea trout and salmon altogether ceased. In so far as practice was concerned the research had achieved, therefore, little or nothing.

RE-AWAKENING INTEREST

Interest re-awoke at about the time of the second world war. Numerous engineering factories containing plating shops were built for war purposes in industrial and rural areas and effluents had to be discharged to local streams or sewers. But it soon became apparent that there was no really satisfactory body of knowledge on the treatment of electroplating wastes. To assist in the safe disposal of wastes from wartime factories, and later from ordinary peace-time industrial undertakings, a whole series of investigations were therefore undertaken at the Water Pollution Research Laboratories. Some of the papers in which the results of the investigations were reported are included amongst the references. It is interesting to study them because as the years pass they reveal a steadily increasing understanding, by those working on the problems, of the factors which are really important. Several things needed to be and were discovered. It had to be found, for example, at what degree of dilution a cyanide salt would be destructive of fish.[4] In the late 'forties it was known that solutions of more than 0·1 part per million of HCN were toxic to trout. By 1953 it had been determined that the really safe level was in the region of as little as 0·01 part per million.[5] This figure (after allowing for any dilution that may occur) settles the standard to which a safe effluent must conform.

Many works, rather than treat the wastes themselves to standards satisfactory for discharge to a local watercourse, prefer to discharge them to the sewers. But cyanides in sewers, unless below a certain degree of concentration, can set up conditions dangerous to men working in the sewers; furthermore the presence of cyanides can adversely and seriously affect methods of treatment of sewage at the sewage works. In a paper published in 1948[5] it was shown that a percolating filter can become acclimatised to the presence of cyanides in the sewage. But it was also shown that if the concentration was at all high the filter took many weeks to do so and that its performance was very adversely affected in the meantime. It was recommended, therefore, that in a mixture of sewage and waste waters reaching a sewage works the concentration of HCN should not exceed 1 to 2 parts per million. It was also shown that such a filter was capable of purifying its effluent of cyanide satisfactorily. Later, very similar conclusions were reached about the effects of cyanides on activated sludge methods of sewage treatment.[6]

Whether or not, therefore, cyanide wastes were to be discharged to the sewers, it was still desirable to discover methods of treatment at the works which would prove both cheap and easy to apply. At the time when the W.P.R.L. investigation began, the treatment usually used in this country for cyanide wastes was by ferrous sulphate and lime, the same in principle as one of the methods earlier recommended for treatment of cyanide in coke oven effluents. The chief disadvantages of this process were that removal was incomplete and much sludge difficult to dispose of satisfactorily was produced. Those disadvantages did not apply to destruction by chlorination,[7] which had at that time come into use in America and on the Continent of Europe, especially in Germany. But that process was ill-understood and was applied in a very rule-of-thumb way and with no real understanding of the reactions involved. W.P.R.L. investigations demonstrated precisely what reactions did take place, the optimum conditions for operation were found, and a practical method of applying the treatment was worked out and demonstrated on a pilot scale. From 1955 onwards papers emanating from the Laboratory show the authors more and more completely in command of the subject and more and more fully able to advise with confidence upon the disposal of

* The first article in this series related to the work of the National Engineering Laboratory on certain aspects of Hydraulics. It was published in our issues of April 29 and May 6, 1960.

plating wastes of all kinds ;[8, 9] including chromates and wastes containing nickel which need separate treatment.

Oil from Engineering Factories

Pollution of surface waters by oil was another of the problems which became particularly acute during the second world war, to some extent because of the building of "shadow factories" in rural areas.[10 11] There are two aspects to this problem. First, surface waters can be polluted by storm water run-off contaminated by films and globules of oil, generally not emulsified ; and secondly, surface waters can be polluted and difficulties created at sewage works by the discharge of waste emulsions of cutting oils. As the methods of dealing with these two types of pollution are different it is necessary to deal with them separately.

Clearly unemulsified oil can be separated by inducing quiescent conditions of flow, so permitting the oil to float to the surface where it can be trapped by baffles and drawn off by suitably arranged adjustable penstocks. Unfortunately, however, there was little information available at the time the situation became acute on which to base the design of tanks in which the right conditions could be realised, and the best that could be done was to specify empirically a period of retention (six minutes) based on a German specification for grease traps.[9] This period of retention was to apply to the peak flow of storm water run-off, and the estimation of this involved further uncertainties in assessment of the permeability characteristics of the catchment area and the likely maximum intensity of the rainfall. In addition to the provision of an interceptor at the storm water outfall, the Laboratory also recommended at that time, as, of course it still recommends, that all possible precautions should be taken to prevent at source the leakage and spillage of oil.

Emulsified oils cannot, of course, be separated in a gravity separator. It is necessary, therefore, to devise a practical system of bringing all such material to a central point where a plant for chemical treatment can be provided. A suitable method of chemical treatment has been worked out in the Laboratory. In working it out a considerable amount of guidance was available from the general principles of colloid chemistry. Thus, many oil emulsions are negatively charged, and it is known that one method of breaking emulsions is to add an electrolyte containing a multivalent ion of charge opposite to that of the emulsified droplets. This works on many cutting oils. Floor washings are best treated by acidification to destroy the soap emulsifier. Treatment with an electrolyte (aluminium sulphate) in acid solution usually works on mixtures of cutting oils and with emulsified floor washings. In the present state of knowledge, however, it is advisable to carry out laboratory tests to find the best method of breaking any particular emulsion.

References

[1] "The Toxicity of Mixtures of Poisons," by B. A. Southgate. *Quarterly Journal of Pharmacy and Pharmacology*, 1932, Volume 5, pages 639–648. W.P.R.L. Reprint No. 28.

[2] "The Effect of Cyanides on the Gill Colour of Fish," by R. Bassindale, B. A. Southgate, and F. T. K. Pentelow. *Journal of the Marine Biological Association*, 1933, Volume 18, pages 671–676. W.P.R.L. Reprint No. 26.

[3] "An Investigation of the Toxicity of the Coke Oven Effluents Discharged into the Estuary of the River Tees," by B. A. Southgate. *Gas World*, 1933, Volume 98, Coking Section, page 14. W.P.R.L. Reprint No. 41.

[4] "The Influence of Dissolved Oxygen Concentration on the Toxicity of Potassium Cyanide to Rainbow Trout," by Kathleen M. Downing. *Journal of Experimental Biology*, 1954, Volume 31, pages 161–164. W.P.R.L. Reprint No. 256.

[5] "The Effect of Cyanides on Treatment of Sewage in Percolating Filters," by A. E. J. Pettet, and H. N. Thomas. *Journal and Proceedings of the Institute of Sewage Purification*, 1948, Part 2, pages 61–68. W.P.R.L. Reprint No. 170.

[6] "Effect of Metal Finishing Wastes on Sewage Purification," by A. E. J. Pettet. *Trans. Inst. Met. Finishing*, 1955, Volume 33, pages 1–28. W.P.R.L. Reprint No. 283.

[7] "Destruction of Cyanide in Waste Waters by Chlorination," by G. E. Eden, B. L. Hampson, and A. B. Wheatland. *Journal of the Society of Chemical Industry*, 1950, Volume 69, pages 244–249. W.P.R.L. Reprint No. 197.

[8] "Treatment in Great Britain of Industrial Waste Waters Containing Cyanides," by B. A. Southgate. *Water and Sanitary Engineer*, 1953, Volume 4, pages 213–217. W.P.R.L. Reprint No. 240.

[9] "Treatment of Plating Wastes and Cyanides," by A. E. J. Pettet. Institute of Sewage Purification Symposium on Trade Wastes, April 9, 1957. W.P.R.L. Reprint No. 307.

[10] *Normung der Fettabscheider Gesundheits Ingenieur*, 1935, Volume 58, 164.

[11] "Prevention of Pollution by Oil from Engineering Factories," by C. Hogg, A. E. J. Pettet, and W. F. Collett. *Journal and Proceedings of the Institute of Sewage Purification*, 1947, Part 2, pages 155–170. W.P.R.L. Reprint No. 159.

[12] "New coking installation of Dorman, Long and Co., Ltd." *Colliery Guardian*, 1937, Volume 155, pages 49 and 95.

COMMENTS FROM INDUSTRY

Vauxhall Motors, Ltd., Luton

This firm installed its first plant for the treatment of cyanide wastes in 1952, which has acted as a model for that built since, and for the design of other plants installed in a variety of factories since then. It was designed by Wallace and Tiernan, Ltd., in the light of the experiences of its American associates and the published work of the W.P.R.L. which also advised upon, and took a direct interest in, this first plant. The present plant for treating acid and chrome wastes was designed entirely by Vauxhall's own staff. We make no further excuse for making rather extensive reference to it.

The plant is handling flows averaging 125,000 gallons per day of wastes from a number of plating shops within the factory area, together with effluents from certain heat-treatment shops and pickling plants. The effluent from the plant is discharged to the local authority's sewers and has to accord with standards which that authority sets down. The local authority is strict, as the effluent from its sewage works passes into the River Lea, from which some of the water supply of London is drawn.

As very strict control of the quality of the effluent from the plant is essential, the firm strongly favours a batching process of treatment. The advantage of batch treatment, it holds, is that each tankful of waste liquor can be sampled before and after treatment, and the arrangement is such that no batch is discharged to the sewers until it is approved as of suitable quality by the control chemist.

Owing to the restricted nature of the factory site within a valley the treatment plant stands at a higher level than the shops from which effluent is drawn. The wastes from the various shops therefore drain to central pumping plants which transfer them to the treatment plant, pumping up cyanide wastes separately from acid wastes. About 2 per cent of the whole amount arises at small shops and these wastes drain to blind sumps whence they are transported to the pumping

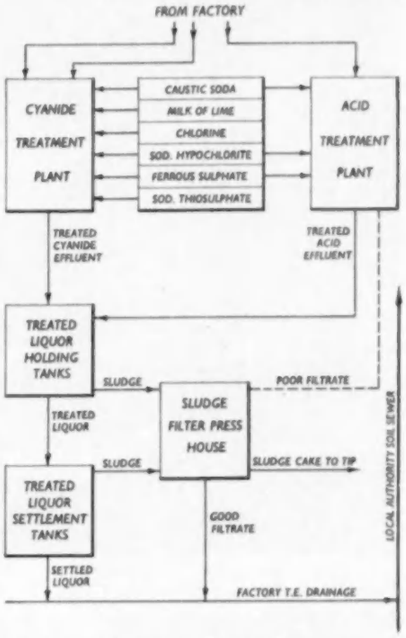


Fig. 1—Trade effluent treatment plant flow diagram

plant by tanker vehicles. The arrangement of the treatment plant is shown diagrammatically in Fig. 1.

Cyanide Treatment.—The method of cyanide treatment is alkaline chlorination. The plant contains six treatment tanks, each of 12,000 gallons capacity, arranged in two lines of three tanks down each side of a central control corridor, Fig. 2, which contains the valves on inlet and outlet pipework associated with each tank. The treatment tanks are constructed in unlined concrete and all pipework and valves are steel and cast iron rubber lined. At the end of the corridor is the main operating space containing chlorinators, injection pumps and a

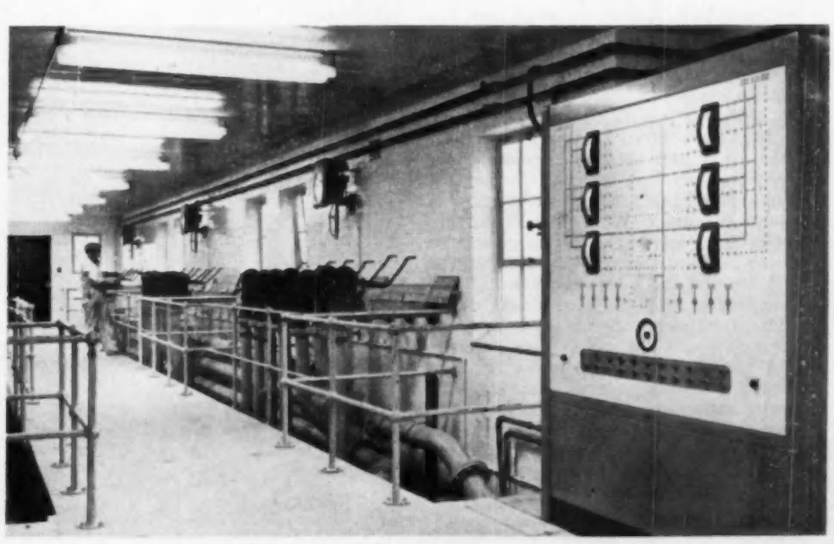


Fig. 2—Central control corridor of effluent treatment plant at Luton works of Vauxhall Motors, Ltd.

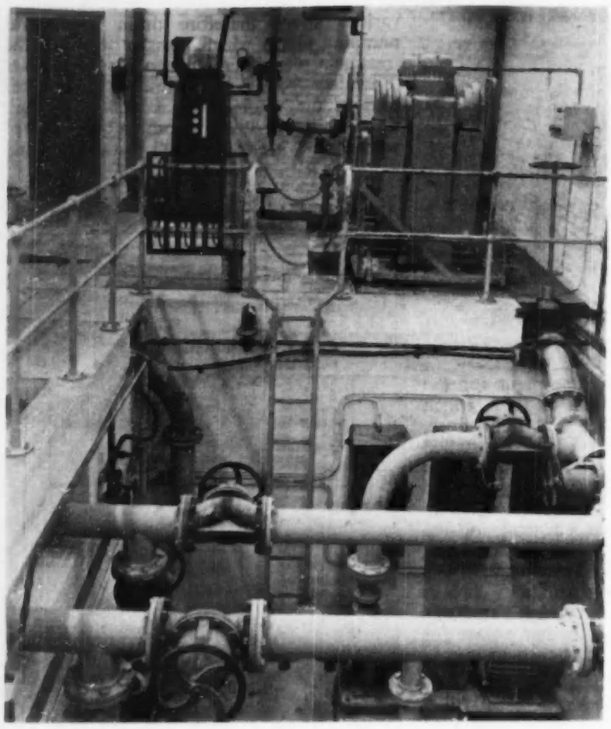


Fig. 3 — Circulating pumps, injection pumps and chlorinator for the cyanide plant

well, Fig. 3, containing two circulating pumps, each serving one line of three tanks, and a third pump which acts as standby to the other two, and can be used for transferring liquor from any one treatment tank into any other of the remaining five tanks. Adjoining this operating space on one side is a room containing tanks of treatment chemicals from which the injection pumps draw, and at the back is the chlorine store, with capacity for sixteen drums of liquid chlorine manifolded and feeding the two master chlorinators in the injection pump area. A bleed-off is taken from each circulation pump delivery to feed continuous-flow pH electrodes to give continuous pH metering during treatment, and to feed a titration panel so that periodic titrations may be made with starch-iodide solution to check for chlorine excess as a guide to completion of treatment.

The procedure of treatment is to open the suction and delivery valves on the tank to be treated and circulate the contents by drawing from the bottom of the tank, through the circulation pump and injecting back into the tank. *En route* from the pump delivery back to the tank the continuous sample is bled-off for pH check and titration ; caustic soda and/or lime slurry are injected to maintain optimum pH ; and sufficient of the flow is by-passed through a loop main containing the chlorinator injector throat to create the necessary vacuum conditions to operate the chlorinator and draw chlorine into the circulating liquor. When a chlorine excess reaction is obtained the circulation of the liquor is continued for half an hour to ensure mixing and check that the excess remains. Following a laboratory check of a sample to ensure completion of the treatment the chlorine excess is removed by the injection of sodium thiosulphate and the contents of the treated tank discharged to one of the treated liquor storage tanks via the control pump house.

Facilities also exist for injecting sodium hypochlorite in the event of a chlorinator being out of commission or a need to increase the chlorine dose when treating an unusually heavily contaminated tank of liquor.

Acid Treatment.—Acid treatment is by the addition of ferrous sulphate to reduce chromium to the trivalent form and pH adjustment with caustic soda to convert metals to their hydroxides in order that they may be removed by precipitation. The plant contains eight treatment tanks, of 25,000 gallons capacity each, arranged in two parallel rows of four tanks each. The treatment tanks are linked in pairs, the two tanks of each pair being one in each row, and each pair is connected to one circulating pump. Each pump can circulate the contents of one of its tanks at a time and can also transfer the contents of either of its tanks to the other of the pair or any of the remaining six treatment tanks. The space between the two rows of tanks contains the inlet and outlet valves and pipework, the four circulating pumps and a small air compressor for supplying air to all parts of the plant for operating remote valves, contents gauges and flow meters. Over the space between the two rows of tanks is constructed an operating corridor, Fig. 4, containing pump starters, valves on chemical feed lines and air cocks controlling remote air-operated valves in the space below. The treatment tanks are constructed in concrete with acid and alkali resistant brick linings; operating pipework and valves are of steel and cast iron rubber lined and chemical feed lines are in semi-rigid ebonite and plastic.

At one end of the plant there is a room containing bulk storage tanks for caustic soda liquor and sodium hypochlorite and in an adjoining area an acid resistant brick-lined concrete hopper for receiving ferrous sulphate in bulk and mixing it into solution with acidified water. These bulk liquid chemical storage points feed the acid treatment plant in which they are housed and supply the smaller treatment chemical holding tanks in the cyanide treatment plant. The procedure of treatment is to open the circulation inlet and outlet valves on the tank to be treated and start the appropriate pump to mix the tank contents by drawing from the bottom and discharging back into the top of the tank. A sample of the mixed tank is then titrated to estimate the doses of treatment chemicals required. With circulation still in progress the estimated dose of ferrous sulphate solution is pumped into the treatment tank through its chemical feed line, which enters through the tank roof from the operating corridor. After this a further sample is checked to ensure that all hexavalent chromium has been reduced to the trivalent form and, this being so, caustic soda liquor is added in the same manner as ferrous sulphate solution to raise the pH value to the optimum for precipitation. Circulation of the liquor is maintained throughout this time, and when the pH value has settled down steadily at the required value a further sample is submitted to the Laboratory for approval, following which the treated contents of the tank are discharged to one of the treated liquor storage tanks, via the control pump house.

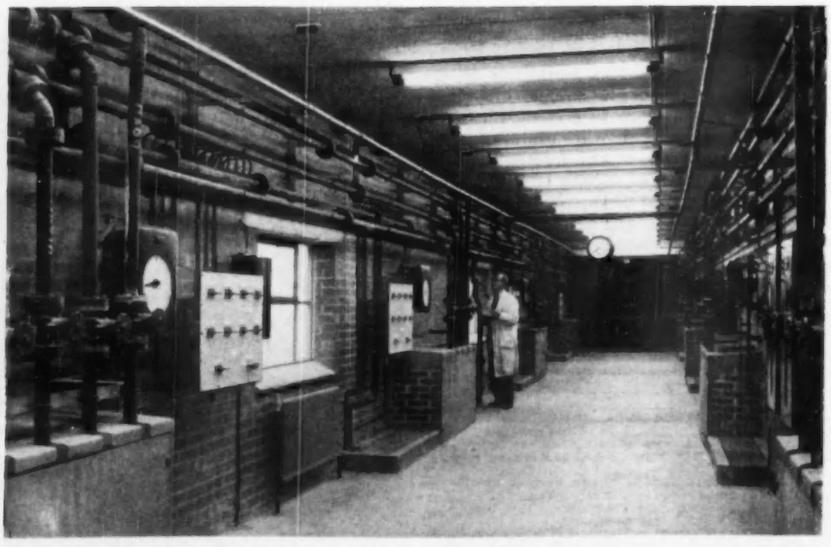


Fig. 4—In the acid treatment plant the operating corridor contains pump starters, valves on chemical feed lines and air cocks for remote control of valves

Treated Liquor.—All treated liquor from the acid and cyanide treatment plants has to pass through the control pump house *en route* to the sewer, via the settlement tank, and the pumps used for tranferring the treated liquor through this final stage are housed in the basement of the building, together with the pumps used for transferring settled sludge to the filter press house. At ground level in the pump house the pump delivery valves are operated, by hand, and instrument panels contain high level alarms from the factory pumping stations ; recorders on the raw effluent pumping main deliveries from the factory to the treatment plant ; and flow and pH recorders and control gear to record and control to preset values the rate at which settled treated effluent is discharged to the sewer. From the treatment plant site the settled treated effluent is pumped to the factory main trade effluent drainage system, which ultimately discharges to the local authority's main sewer, together with all other factory discharges, including domestic sewage.

Adjoining the control pump house are four circular settlement tanks of conventional design, with peripheral weirs and rotary sludge scraping mechanisms. Two of these tanks are used alternatively for receiving and storing treated effluent, direct from the treatment plants. When one of the tanks is full a sample of the mixed contents is sent to the Laboratory for final check while filling of the second tank commences. Following Laboratory approval of the mixed sample, the contents of the full tank are pumped through the remaining two settlement tanks in parallel working on normal continuous flow principles, settled liquor discharging over the peripheral weirs to the sewer and sludge being removed from centre wells in the bases of the tanks and pumped to the filter press house sludge storage tank.

Sludge.—The filter press house contains two sixty-chamber 31½in square filter presses with cast iron recessed plates, clothed with sisal-backed nylon cloths, manually closed and with hand-operated hydraulic jacks. Sludge from the settlement tank is stored in a 6000-gallon pressed steel storage tank outside the building, from where it is pumped by three pumps controlled by pressure switches into the filter presses on the floor above. Under the filter presses is a parking space for a truck to stand, so that the pressed filter cake can be dropped straight into the truck and taken to the final tip. Filtrate from the presses drains to a 3000-gallon storage tank outside the building, from where a fourth pump delivers the filtrate direct to the treated effluent sewer or back to the acid treatment plant to go through the treatment procedure again, according to its condition.

The firm strongly believes in the value of the work of the Water Pollution Research Laboratory which it consults when confronted with an appropriate problem, such as arose recently in connection with the treatment of oily wastes.

W. CANNING AND CO., LTD., BIRMINGHAM

This company is a supplier of electroplating plant and materials ; although it is not directly concerned with treatment plant for effluents and plating wastes, advice is very frequently sought on the methods necessary for dealing with the particular chemicals that are used in the plating processes. Customers generally are referred to specialised treatment firms for suitable types of effluent plants to cope with the wastes. The electroplating plants produced by this company are, however, designed to ease the treatment problem as far as possible. The use of drag-out tanks is particularly advocated. Articles after plating are first of all placed in a tank capable of drawing off a very large proportion of the plating liquor before being moved on to the rinsing water which is itself arranged for counter-flow. The liquor in the drag-out tank can be returned to the plating tanks with an obvious economy ; and a reduction of the flow to the treatment plant. The counterflow arrangement creates a strong effluent which is advantageous for treatment.

Results of the work of the D.S.I.R. have not materially altered the general construction of plating plants, but the firm's representative agreed that the methods it used to ease treatment problems were as recommended by the Laboratory.

A point of great significance brought out in the discussions was that the cost of an effluent treatment plant for a small plating shop might quite easily exceed that of the plating plant itself, which explains why many engineering firms with a small volume of plating prefer to have this dealt with by the established trade plater, who already has the necessary equipment.

(*To be continued*)

North-East London Railway Electrification

With the introduction of electric trains to Chingford, Enfield, Hertford and Bishop's Stortford on November 21, steam traction was all but eliminated on the Great Eastern Line suburban routes from Liverpool Street. The lines now converted operate on the high-voltage single-phase a.c. system, using 6·25kV in the inner area and 25kV from a point just south of of Cheshunt station.

FOLLOWING the changeover of the Liverpool Street–Shenfield–Southend (Victoria) services from 1500V d.c. to 6·25kV a.c. on November 4-6, the second suburban outlet which diverges northwards from the main line through Stratford at Bethnal Green was formally inaugurated as an electrified route on November 16, preparatory to public train services on November 21. This latest conversion has covered some 45 route-miles previously served by steam or diesel trains. As seen in Fig. 1, it extends as far as Bishop's Stortford on the main line to Cambridge, and includes the branches to Chingford, Enfield Town, and Hertford (East). Instead of following the main Cambridge line throughout, the electrification makes a loop to the west of it between Hackney Downs and Cheshunt. As far as Lower Edmonton the loop is formed by part of the Enfield Town line, and from there to Cheshunt it has been completed by rehabilitating a 5-mile section of line through Southbury (formerly Churchbury) which had not carried regular passenger services since 1909. The three passenger stations on this part of the loop have been completely renovated and adapted for the new services.

In this electrification the contact wire is fed at 6·25kV from Liverpool Street to a point just south of Cheshunt station, and at 25kV beyond. There are five feeder stations —at Bethnal Green, Silver Street, Wood Street, Rye House and Bishop's Stortford—all of which have direct connection with C.E.G.B. or area board supplies at various voltages. Lineside power cable routes are therefore confined to short stretches between the feeder stations and the overhead switching structures where connection is made with the contact wire. This arrangement is more in keeping with the original prospectus of high-voltage a.c. electrification than the use of cable routes and sub-feeder stations. On the other hand, connection to several different sources of supply increases the number of neutral sections required to separate them in the overhead contact system. Such sections occur between feeder stations, at certain track-sectioning cabins, and at the voltage changeover point south of Cheshunt. The track-sectioning cabins associated with neutral sections are at Clapton, Stoke Newington and Southbury. These have two-section switchboards with normally-open bus-section switches.

Track-sectioning cabins with single-section 6·25kV switchboards are provided at Liverpool Street, Hackney Downs, Bury Street Junction, Chingford and Enfield Town. At Harlow and Hertford (East) track-sectioning cabins, there are 25kV single-section switchboards. At Cheshunt voltage-changeover neutral section the 25kV and 6·25kV switchboards are installed in the track-sectioning cabin, together with a 3MVA, 25kV/6·25kV transformer.

Feeder stations normally supply the tracks on either side over a distance approximately

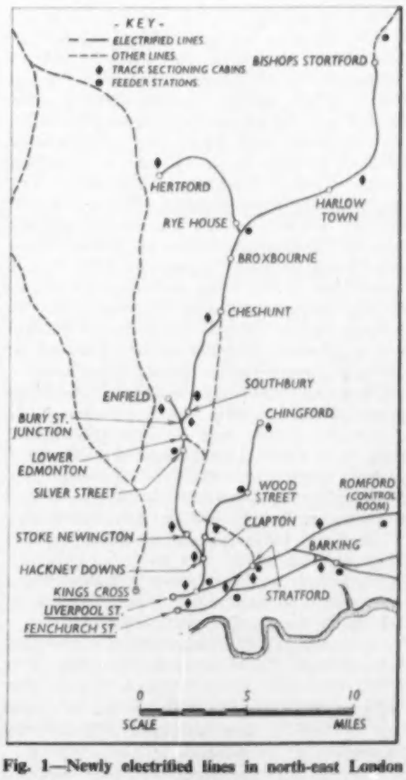


Fig. 1—Newly electrified lines in north-east London

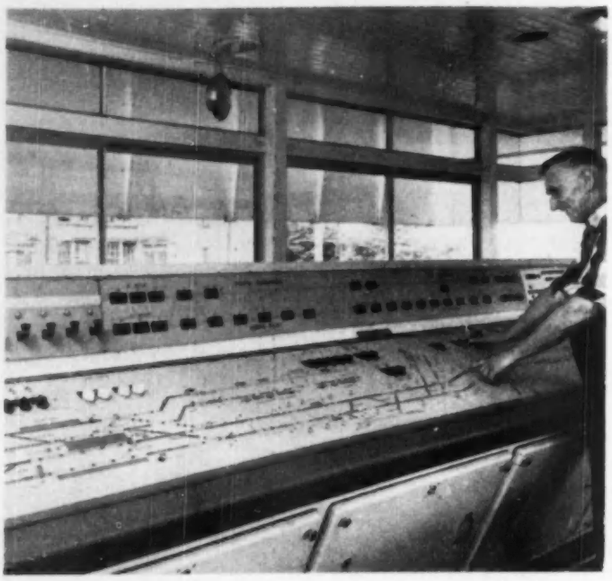


Fig. 2—Operating panel at Hackney Downs signalbox. Single-aperture indicators with dual colour displays economise in space required

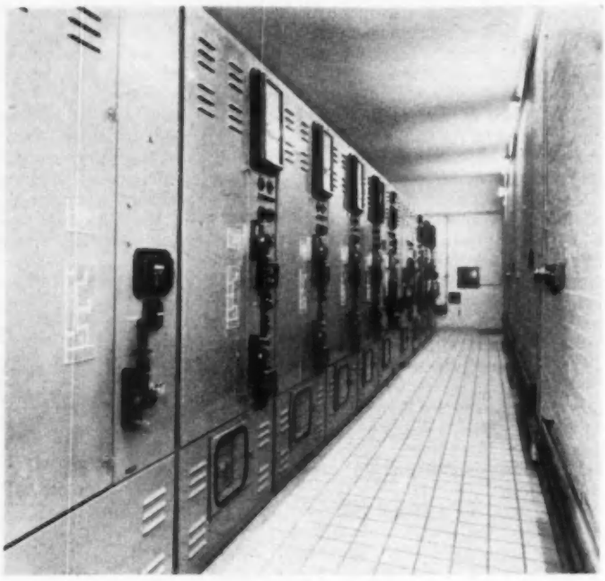


Fig. 3—Interior of Rye House feeder station on the 25kV section of the new electrification

halfway to the next one. Where occasion demands, neutral sections and their associated switches have been positioned so that when any one feeder station is out of action, through feeding can be extended to cover the tracks towards the next operative feeder station. At Bishop's Stortford the feed is for emergency purposes only and the feeder station there has been designed as a mid-point track-sectioning cabin with a two-section 25kV switchboard, incorporating a bus-section switch, as it may ultimately be required to serve in this manner for the extension of electrification to Cambridge, when another supply point would become available.

Permanent magnets are fitted in the track in the 6ft way at the voltage changeover point, and at neutral sections, to act in conjunction with magnetic receivers on the rolling stock which initiate opening and reclosing of the motor coach circuit breakers, and adjustment of transformer connections when required by a change of voltage. Service trials of this system were undertaken on the Colchester–Clacton–Walton electrification of 1959, but its first operational use was on the Glasgow suburban electrification during driver training running later in the same year. One of the problems which has had to be overcome was that of an induced voltage in the "dead" sections of contact wire sufficient to disturb the operation of the voltage detection relays in the rolling stock.

Outgoing track feeder circuit breakers are generally fitted with distance impedance protection, set to trip on forward current only, with thermal protection as a safeguard against persistent faults of a magnitude similar to peak traction loading. Where a circuit breaker is used to parallel two tracks, it is fitted with simple overcurrent and thermal protection.

Incoming feeder circuit breakers have overcurrent protection which forms a back-up for the distance impedance protection.

An automatic reclosing feature is provided on all track feeder circuit breakers. For 25kV, the reclosing time interval is adjustable between two seconds and ten seconds, and for 6·25kV it can be varied between ten seconds and 120 seconds.

High-tension switchgear has been supplied by Fuller Electric, Ltd., and South Wales Switchgear, Ltd.; and main power transformers by C. A. Parsons and Co., Ltd.; and Bruce Peebles and Co., Ltd. Power supplies are under remote supervisory control from Romford control room, using the Standard Telephones and Cables frequency-modulated system described in our October 7 issue, page 590.

The overhead contact system consists of simple catenary with an 0·166 square inch solid grooved cadmium copper contact wire suspended by droppers from a 19/0·083 stranded cadmium copper catenary. For comparative purposes short sections of simple catenary with stitch wires have been installed. Although the stitch wire system tends to relieve hard spots at points of suspension, erection and adjustment are more complicated. Simple weight-tensioned construction without stitch wires is therefore used for the major part of the scheme. Neutral sections are formed of four gaps using either carrier wires or section insulators. The contractor for the overhead equipment was British Insulated Callender's Construction Company, Ltd.

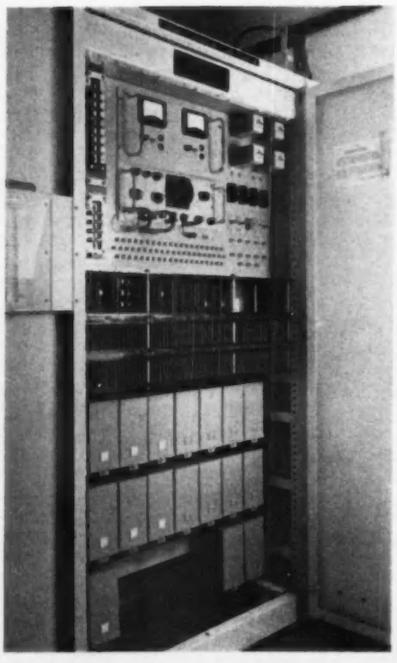


Fig. 4—Cubicle of "Westronic" equipment at Hackney Downs for remote control of interlocking at Clapton

Existing track circuits and colour-light signalling from Bethnal Green to Enfield Town, and from Hackney Downs to Chingford, had to be immunised for working under a.c. traction conditions. A new signalbox was built at Hackney Downs for direct control of the junction area and remote electronic control of an unattended interlocking at Clapton Junction, approximately 1¼ miles away. Fig. 2 shows the Westinghouse control panel, which operates on the push-button route-setting principle, controlled by buttons on the track diagram. Main signal indications are given by single-aperture units which show red or green through an arrangement of internal colour filters to which light is piped by "Perspex" tubes. Where a signal has a subsidiary aspect, two lights are provided on the panel, that for the subsidiary being normally out, but showing green alongside the normal red of the main aspect indication when the subsidiary aspect clears. Routes are indicated by single-aperture light units with internal filters which show white when a route is set up and change to magenta as the track-circuits are occupied. Magenta was chosen to avoid possible confusion between route and signal aspect indications.

A cubicle of the "Westronic" apparatus for remote control from Hackney Downs of the Clapton interlocking is shown in Fig. 4. This is a fully-transistorised system which continuously scans the condition of all relays by means of interrogating pulses, and generates return indications on different frequencies according to the condition of the relay contacts. Some further details were given in our September 16 issue, page 461, in connection with similar installations on the Manchester–Crewe electrification. Printed circuit cards jack into the cubicles as shown in the accompanying illustration, and an oscilloscope is built into each terminal

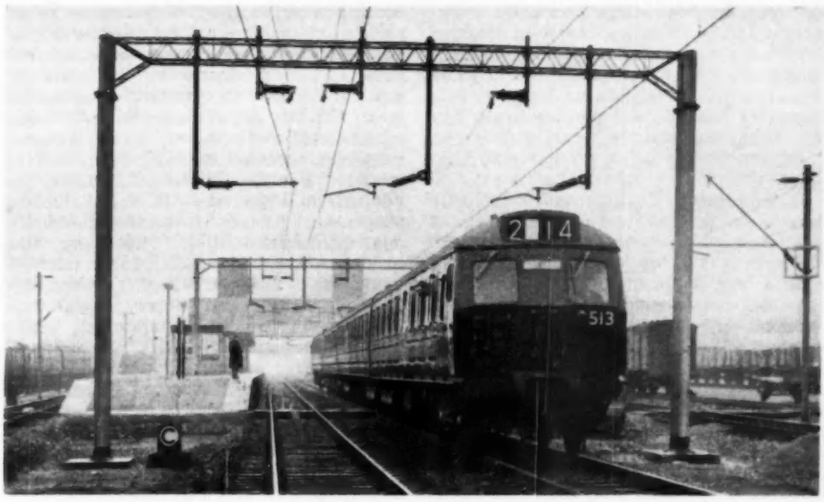


Fig. 5—Four-car multiple-unit set leaving the new station at Broxbourne

equipment to facilitate routine circuit checks. There is a further "Westronic" installation at Harlow Mill for remote control and indication of the Harlow Town station area.

New signalboxes were built at Broxbourne, Harlow Mill, and Ware, the first two having route-setting panels and the third a twenty-five-lever mechanical frame with cut-down levers controlling the colour-light signals and levers of full length operating mechanical connections.

Four lifting barriers have been installed at Ware level crossing. Each is 28ft long, and they are controlled by push-buttons in the signalbox, which overlooks the level crossing. Each barrier is driven by a 24V electric motor. As a warning to road traffic, red lights flashing at the rate of between fifty and seventy times a minute light up five seconds before the barriers begin to lower, and continue flashing until the barriers are raised again. On operating one of the push-buttons on the pedestal in the signalbox, the left-hand barrier of each pair (viewed from the road) begins to fall. When these two barriers have completed their movement, the other pair falls too. As each barrier drops, a collapsible fringe, which folds against the boom when it is vertical, opens out to prevent animals from straying on to the crossing when the barriers are down. The second push-button is for raising the barriers.

The barriers are painted in red and white, and "Scotchlyte" reflectorised strips are attached to each boom. These, together with electric lamps, enable the barriers to be easily seen during darkness.

The Westinghouse Brake and Signal Company, Ltd., was the contractor for the signalling work, including the level crossing barriers. Other contractors concerned with the supply of equipment were Pirelli-General Cable Works, Ltd., British Insulated Callender's Cables, Ltd., and Ericssons Telephones, Ltd., and Standard Telephones and Cables, Ltd., for train describers and signal post telephones.

Telecommunications cable work included the supply by the B.I.C.C. Group of 120 miles of aluminium-sheathed telecommunication cables and accessories for the section of the route between Bury Street Junction, Enfield, Hertford East, and Bishop's Stortford. The majority of this cable, requiring more than 200 terminations, is being installed by British Insulated Callender's Construction Company, Ltd. Three main cables between Bury Street Junction and Bishop's Stortford comprise a twenty-four-pair audio quad cable for traction supervisory and electrification telephones, a fifty-four-pair audio quad cable tapering to twenty-four pairs at Bishop's Stortford for feeder stations and signalboxes, and a seventy-two-pair composite cable containing audio and carrier quads to provide long-distance circuits. Similar cables containing a reduced number of pairs are being laid from Broxbourne to Hertford East, and Bury Street Junction to Enfield Town. Extensible B.I.C.C. deep-driven copper earth rods have already been installed at 1000 yard intervals along the route and, as the cables are laid, they are connected to this earthing system. These low-resistance earthing arrangements, together with the conductance of the aluminium sheaths, provide screening of the telephone conductors against induced currents.

The multiple-unit trains built by British Railways at York and Doncaster for this scheme, and equipped by The General Electric Company, Ltd., with traction equipments incorporating "Com-Pak" mercury-arc rectifiers, were described in our October 21 issue. Trains on the Enfield Town and Chingford services are formed of three-car sets (battery driving trailer, motor coach and driving trailer), while those running to Hertford (East) and Bishop's Stortford consist of four-car sets having an additional trailer coach. In both formations the motor coaches are equipped with four 200 h.p. motors.

The three-car sets have an acceleration on level tangent track of 1·35 m.p.h. per second, which is suitable for the closely-spaced stations in the inner suburban area, those on the Enfield Town line being only three-quarters of a mile apart on average. Four-car units accelerate at 1·1 m.p.h. per second. Maximum service speed of both units is 75 m.p.h.

A four-car set leaving the new station at Broxbourne for Bishop's Stortford is seen in Fig. 5. This is one of three new stations on the line where older buildings have been demolished, the others being Harlow Town (described in our July 22 issue, page 155) and Enfield Town.

"Electrics" and Electronics in Aircraft

At a joint meeting of the Institution of Electrical Engineers and the Royal Aeronautical Society in London on November 11, Lord Caldecote surveyed the future of "electrics" and electronics in aircraft and guided missiles. His address ranged over the whole field of power generation systems and their application to flight control, navigation and guidance systems, communications, data handling and collision warning. He also discussed some of the more advanced ideas on inertial navigation and new power sources. Extracts from the address are given below.*

IT is apparent that as the performance of aircraft increases and as the air space fills up, there are more and more functions which the human operator cannot control unaided, in fact there are many which he cannot control at all, and electronics and "electrics" must come to his aid. Their function is not merely a convenience to relieve the operator of much of his work, but increasingly, to do jobs which he cannot do unaided. Having released ourselves from the limitations of a human operator we now find that we can do much more than assist him—we can virtually disconnect his muscles and his brain and at our convenience distribute them in a way that enables us to obtain information, and to perform operations previously inaccessible. This, therefore, is where we stand to-day. Progress demands that both manned aircraft and guided missiles fly higher, further and faster; in the host of new problems which arise from these demands not the least are those associated with weight and space saving, with safety, reliability and regularity of flight particularly in adverse environments, and with heat transfer associated with high speed flight.

*Director, The English Electric Company Ltd.

Power Generation

For manned aircraft four systems have survived from the variety which have been used since the advent of the engine-driven generator less than thirty years ago. They are: 28V d.c.; 112V d.c.; 200V, 400 c/s, constant-frequency a.c.; and 200V variable-frequency a.c.

While prominence is often given to the extremes of operation we must not lose sight of the need for simpler systems in light aircraft and other short-range passenger carrying aircraft. For many of these the 28V d.c. system will continue to provide an adequate and economical arrangement especially as developments have now allowed the use of semiconductor regulators with or without magnetic amplifiers, and the advent of the brushless generator has eliminated problems of brush wear. The high currents in such low voltage d.c. systems, however, will limit their power to about 12kW per channel, and we must beware lest the attractive developments now possible do not

introduce complexities which will detract from the basic economy and reliability of these systems.

The 112V d.c. system is used in some of the earlier "V" bombers, but has several disadvantages inherent in relatively high voltage d.c. systems such as radio interference, arcing at contacts and difficult fault clearing. In view of the recent developments in a.c. supplies it is unlikely that this system will survive.

The details of the 200V, 400 c/s, constant frequency systems are familiar but one or two specific problems related to them deserve mention. At present the first element in such a system is an hydraulic constant speed drive or an air turbine. From the aircraft designer's point of view, it is most efficient to reject the heat generated in hydraulic drives at as high a temperature as possible : at present this is limited by the properties of the oil to around 160 deg. Cent. Some further improvement in performance could be achieved by an increase in this temperature by the use of exotic oils. As these units are now of proved reliability and enable any number of channels to be run in parallel, some further development in this or other directions to increase their power/weight ratio might well be worthwhile. Although the next generation of civil aircraft will use this system, other constant-frequency systems using air turbines of one kind or another are already in military service and seem likely to be used in the future, especially in twin-engine aircraft where the ability to operate in parallel is of less value. Quite recently a constant-speed drive was demonstrated using an air motor differentially to add and subtract speed between engine and generator. It is claimed that this drive can also be used with a ground air supply as a starter motor or as a motor to drive the alternators when the engines are stationary. Extensive development is however needed since the air available from an engine at a sufficient pressure and quantity will be at about 600 deg. Cent.; this may well prove to be as serious a limitation in practice as the temperature range of oil used in hydraulic drives.

There are many obvious advantages of a constant frequency a.c. system and the ultimate goal is to provide such a system without the use of complex mechanical constant speed drives with their associated governing and control problems, but with the ability to parallel channels when desirable : the so-called variable-speed constant-frequency (v.s.c.f.) system. The advent of the silicon rectifier and power transistors have made possible the development of static frequency changers of comparatively large power. These can form the basis of a system comprising a brushless alternator, driven at engine speed, delivering a.c. power at variable frequency to a frequency changer (controlled by a crystal oscillator, tuning fork or tuned circuit) with a constant-frequency output. These (v.s.c.f.) systems are now in the early development stage and seem likely to be lighter and more reliable and efficient than any previous system. In every respect they should be most suitable, and should be available, for a supersonic airliner provided development is actively pursued.

The third system in current use is the wild frequency a.c. system. With a brushless alternator this is basically one of the simplest systems but is only suitable when a large proportion of the load is resistive, such as is required for de-icing and cooking. Such a system can also supply power for a.c. motors and, for other requirements, d.c. via rectifiers. Existing electronic equipment normally requires a supply of constant frequency a.c., but the increasing use of semiconductors will encourage the use of more direct current. This trend coupled with increasing domestic and de-icing loads may well bring the wild frequency a.c. system back into favour owing to its basic simplicity.

In the generators themselves heat transfer is an important factor. The development of gallium arsenide rectifiers at least opens the prospect of 300 deg. Cent. operation, and while a high temperature for heat rejection has obvious advantages, there are serious electrical disadvantages. At 300 deg. Cent. we are reaching the limit of available insulating materials which meet the requirements of mechanical strength, stability and space, and special precautions must be taken to prevent oxidation of the copper under the insulation. At about 400 deg. Cent. the magnetic properties of iron start to deteriorate and it therefore seems likely that the upper limits of temperature for the design of generators has nearly been reached, and certainly considerable research into the overall optimum operating temperature is required. Reliable brushless machines, both a.c. and d.c. are now in service and these are likely to be steadily improved over the next decade without any fundamental changes. At first sight the solid rotor alternator seems to have many advantages : the rectifiers are stationary, there is no rotating winding, and the operating temperature is high. But experience so far indicates that these machines will be heavier, and there are many problems in construction not all of which have been overcome. It is too early yet to decide to what extent they will replace brushless machines with wound rotors, which are proving reliable and efficient but there are indications in America that the solid rotor alternator is losing favour ; further development and investigation is required.

Electrical power sources in missiles present a largely different problem. The alternatives now being used are d.c. from rechargeable or "single-shot" batteries and a.c. from alternators normally driven by hot gas turbines. Rechargeable batteries or conventional dry batteries are not convenient owing to storage problems. However, modern "single-shot" batteries can be made with a good shelf life and although they cannot be tested, do provide a reliable source of power and are being used in medium-sized missiles. Improvement in their performance, particularly in low temperature conditions would widen their application.

A.c. systems are widely used even for small missiles with time of flight less than a minute, and it is often convenient to use the prime mover also to provide power for hydraulic pumps and actuators.

For small and medium-sized missiles the relative advantages of alternators or batteries are fairly evenly balanced and the choice will depend on the particular requirements of each system. For larger missiles with large times of flight and greater electrical power requirements, a.c. systems will predominate, while for space vehicles one of the more modern developments mentioned later in this paper will be used.

Power Distribution and Protection

An important element in the reliability of the electrical system of an aircraft is the distribution system together with its protective arrangements. Owing to their relatively short flight times these problems are less relevant in missiles at present, but will become vitally important in manned space vehicles of the future. Up to now wiring and insulation developments have broadly kept pace with increasing performance, and ambient temperatures encountered in a Mach-2 aircraft can be met using existing insulators based on silicone elastomer glass fibre constructions with fluoro-carbon insulators available for particular high spots. For Mach-3 aircraft with high ambient temperature conditions the use of wholly mineral insulated cable, and plugs and sockets with ceramic insulated internals will be required. However, the mating elements of plugs and sockets already represent a temperature barrier as migration and oxidation place a limit on silvered mating surfaces. These remarks apply equally to crimped connections, terminal tags and the like. Solid nickel surfaces in contact show promise but the whole subject is one which requires intensive and urgent development, for in both aircraft and missiles plug and socket connections are a frequent source of unserviceability. Fortunately the advent of micro-miniaturisation will lead to the combination of more units in one assembly, and therefore to fewer plugs and sockets, and to less wiring exposed to the extremes of environmental conditions.

Protective and other switching devices also require considerable development to improve reliability and reduce weight. Development in two directions is likely : sealed switches, relays and circuit breakers, filled with inert gas are being developed and in the lower current ranges are already available, though the British equipment industry has lagged behind America in this field. Now similar development is needed on higher current devices such as circuit breakers able to break fault currents of 200A at 400 c/s. Developments in the atomic energy field are producing reliable sealed microswitches made of stainless steel and ceramics which will be of value to the aircraft designer for high temperature applications. The ultimate aim must be to eliminate as many moving contacts as possible and in the never-ending search for lightness combined with reliability the trend to replace relays and switches by semiconductor devices with no moving parts will continue.

Ultimately as new circuit and micro-miniaturisation techniques become available, it will be possible to confine a greater proportion of electronic and electrical equipment to areas where the environment is controlled and some of our present problems will disappear ; until this time, which is many years away at least for civil aircraft, development of components able to operate reliably in the ruling ambient condition must be continued.

Component and Techniques

The progress which has been made over the past ten years in the development of electrical components and techniques has been of the greatest significance in both aircraft and missiles. Much of the stimulus has indeed come from the necessity to compress more and more complex circuitry first into military aircraft, then into guided weapons and now into space vehicles ; this is one of the factors which make it essential for this country not only to continue missile development but now to take a substantial part in space research. Already civil aircraft and industry generally are benefiting from this progress ; high-powered radar, doppler techniques, semiconductors, computers and microminiaturisation are a few examples.

Of all these, microminiaturisation probably has the widest application and is likely to have an increasingly important impact in the future. Developments are now proceeding along three distinct lines: the flat component, the flat circuit and the solid circuit.

Three separate objectives can be distinguished in each of these. First the production of a high ratio of useful to parasitic mass and volume on the electronic parts. Secondly, a minimum of internal hand-made connections and thirdly an elimination of internal non-productive mass such as sockets, connectors, protective coverings, &c.

The essence of the flat component technique is to standardise the size and shape of all components. For instance, components can be in the form of circular wafers which are stacked with interleaving insulating material, the circuit being formed from a stack of elements connected on the outside of the wafers. Such units are known as micro-modules.

The flat circuit technique involves forming complete circuits on the surface of small insulating plates. Active elements such as transistors are inserted like minute "Aspirin" tablets into recesses and connected to the remainder of the circuit.

The solid circuit technique is probably the nearest to the ultimate solution of the micro-miniaturisation problem—the idea being based upon developments taking place in solid state physics. It has now been found possible to build on a single crystal of semiconductor material multiples of transistors, diodes and resistances by suitably processing minute areas of the crystal surface. Thus, a complete block of circuitry is created on the semiconductor material itself. Application of the solid circuit is now being actively studied, but it will be many years yet before they will be an economic proposition in aircraft.

However, the flat components and flat circuit techniques may well be developed rapidly over the next ten years, although expert opinion differs on their relative merits. The former can be used in development where the time from circuit design to manufacture must be kept as short as possible. But the flat circuit is a less flexible technique and is more suitable for application where changes in circuitry are less likely enabling the design to be frozen at an earlier stage, and where a manufacturing process can be set up to make relatively large quantities. The technical problems associated with these two techniques are also somewhat different; whereas the main difficulty with the flat component is to make the side connections, the problem with the flat circuit is to produce a number of different components both reliable and to a close tolerance so as to ensure that the completed circuit will be within specification.

Other developments in this field, which will become of importance during the next decade, are the parametric amplifier and the mesa transistor. The former depends on the principle that energy can be injected into an *LCR* resonant circuit by varying the capacitance of the condenser at a suitable frequency. Its advantage is that high amplifications can be obtained at very low noise levels. The mesa transistor takes advantage of diffusion techniques to obtain a very thin base width for the junction. These transistors have an upper frequency limit of about 300 Mc/s at present, though the theoretical limit is much higher. For medium and low power applications up to, say, 10W at 40 Mc/s they have an obvious future in all airborne electronic equipment.

One of the newer semiconductor devices holding promise for applications with a weight restriction is the Esaki—or tunnel diode. The versatility of this device is such that one tunnel diode will replace the r.f. amplifier, local oscillator, frequency changer and first i.f. amplifier in a conventional receiver. Only the tuned circuits associated with these stages remain, with a great saving in weight and volume. The fast response of the Esaki diode also makes it suitable for use in high-speed computer systems.

The importance of the development of new components, particularly those involving the micro-miniaturisation techniques which I have mentioned, cannot be over emphasised. At present development in this country is not keeping up with that going on abroad and unless this trend is corrected, our aircraft and missile designers will be seriously handicapped in the future, or will have to rely more and more on imported components.

Flight Control, Navigation and Guidance Systems

Now increasing speeds have cut down the time available to the pilot, particularly in the critical take off and landing phases, high fuel consumption and the requirements of air traffic control have made accurate navigation essential for both safety and economic reasons, and the requirements for safe and accurate flying in bad weather have greatly added to the amount of information required to be given to the pilot by his instruments.

This has led to the presentation of information to the pilot in a more intelligible form in comprehensive and better integrated instrument displays, driven by relatively complex servo systems. At the same time auto pilots have been developed to provide more and more facilities such as I.L.S. coupling and altitude hold. In all these fields developments will continue to provide smaller and lighter equipment, and above all, greater reliability. High performance heavy aircraft tend to have smaller safety margins at take off and landing than their predecessors, and this has led to a demand for a take off monitor and improved landing aids particularly in bad weather. Developments in both these spheres will continue and it is but a short step to fully automatic flight control of all types of aircraft with the crew acting largely as monitors and decision makers when difficulties arise.

Flight Control System.—It has been shown that by using multiple systems and comparing their outputs, a sufficient degree of safety can be achieved for automatic landing of passenger aircraft. Automatic flare-out and full automatic landing systems are being developed and excellent progress has been made—quite sufficient to justify the provision being made for these systems in the "VC 10" and "DH121" aircraft—but it will be a number of years before they are in service.

Controls for "V.T.O.L." aircraft, which pose special problems of automatic stabilisation, will certainly require a great deal of thought in the coming years. Special attention is also required to produce a completely reliable blind landing system for all types of "V.T.O.L." aircraft to enable them to land in any weather on a predetermined spot or in an emergency in a ploughed filled or similar unprepared locality. Another sphere in which development is urgently needed is that of heading references. At present it is the heading reference which is the greatest limitation to the accuracy of doppler systems and future developments will be aimed at free or north-seeking gyro systems with long term drift rates not greater than 1 deg. to 10 deg. per hour, such as are already being used for military purposes.

Navigation Systems.—"VOR" has been the standard international short range navigational aid for a number of years and provides track guidance along a selected radial to (or from) the "VOR" beacon. Following a decision taken by I.C.A.O. earlier this year, "VOR" has been supplemented by "DMET," a distance measuring system, to provide full position information. There is little doubt, however, that the "VOR"/"DMET" combination is not sufficiently accurate or flexible for high density traffic areas and some type of area coverage system will be needed in European terminal areas and the Eastern Seaboard of the United States. The Decca phase comparison could meet this need but the necessary international agreement has not yet been achieved. No such agreement is needed for doppler systems and their very high accuracy over short distances makes possible their use in terminal areas; for this application they will need to be coupled to a pictorial display.

Internationally speaking, there is no agreed long range navigational aid. Loran and Consol are both agreed as interim systems and, of course, "ADF" is extensively used. But there is at present no satisfactory ground based system providing world-wide coverage. Any system requiring a large number of ground stations in different countries leads to severe difficulties in implementation. Work has been going on for a number of years on low-frequency phase comparison systems, which require relatively few ground stations, but there is still insufficient information on propagation characteristics to be sure that sufficient accuracy and reliability can be achieved. The use of navigation satellites is clearly a promising direction for future development, but for the near future self-contained aids, either doppler, inertial or more probably a mixture of the two look like becoming the standard systems.

Communications

Much development has been, and will undoubtedly continue to be, concentrated on systems which extract the maximum information from signals in the presence of noise using a given band width and in a given time, and on the development of low noise signal amplifying devices. While it would be dangerous to predict the most likely line of advance, there is no doubt that progress on the first of these—that is in the detection of useful signals in the presence of noise—would be of very wide application. Extraction of weak signals demands correlation techniques which are to some extent analogous to the problem of meeting a stranger at a railway station. If we know something about the submerged signal we can correlate it with a replica of the expected signal and will thus be able to detect the presence of the expected signal in spite of the surrounding noise. These correlation techniques, however, demand extremely complex circuits containing numbers of matched filters, and the advent of semiconductors and microminiaturisation will considerably help the designer in this difficult problem.

An extension to this technique was announced in September at the Symposium on Information Theory. Three American scientists from General Electric described a new technique called "adaptive wave form recognition" which has demonstrated the ability to detect signals buried in noise and to continually adapt the circuit parameters for optimum reception.

In the past much attention has been paid

to the choice of frequency to eliminate unwanted interference and to achieve the most efficient communication channel. This search for new channels will continue at both ends of the frequency spectrum, as for instance the low frequency navigation system which was referred to earlier. For short range communication civil operators will probably continue to use the v.h.f. band at 50 kc/s channel spacing, whilst the development of the u.h.f. band will continue for military aircraft. But for longer ranges h.f. single side band systems will steadily take over from double side band during the next decade, giving improved communication and providing more channels per band. Due to the vagaries of the ionosphere, however, and the severe electrical noise experienced, none of the frequency bands currently used for long range communication is ideal. The best final solution may well be the use of communication satellites allowing the use of v.h.f. and u.h.f. frequencies.

Data Handling

The rising density of air traffic and the short flight time of guided missiles both pose the problem of rapid data transmission and the rapid transposing of this data into usable form. In the case of manned aircraft it is becoming quite outside the capability of human air traffic controllers to assimilate all the information and to make the decisions necessary to ensure the safe and orderly flow of traffic. With increasing speed a similar problem is developing for the aircraft crew and the automatic transmission, processing and display of information in a convenient form is becoming of great importance ; this may well be followed ultimately by the direct control of the aircraft via a data link.

The limits of development in accuracy and miniaturisation of analogue computers are likely to be reached quite soon. Noise, drift and limited resolving power all contribute to this. Digital techniques, however, while offering unlimited accuracy require increasing numbers of digits and consequent increase in circuitry. From the airborne standpoint, digital computers offer this accuracy at a very low power level and lend themselves admirably to miniaturisation. The real limitation in this case is the time required for any problem to be resolved. In this connection the development of the digital differential analyser is of the highest importance since it combines the high working speed of analogue methods with the accuracy and ease of miniaturisation of digital techniques. A complete digital differential analyser comprises a number of integraters, multipliers and other units using digital techniques, which are connected together in analogue computer fashion. The trend now in airborne navigation systems is to perform computation by digital differential methods and this trend will continue for all types of special purpose computers.

I have concentrated on this need for computers as data processing is probably one of our greatest problems both on the ground and in the air, and it is growing rapidly. Large digital computers are needed on the ground for all the air traffic control systems being developed, while in the air, computers are used for flight control and air data systems, navigation systems and, of course, in military aircraft for the attack and bombing functions. I believe there is a strong case for a central general purpose computer which could handle all the work required in an aircraft, including such tasks as fuel and flight management.

Airborne Radar and Collision Warning Systems

As the air space becomes more and more congested and average speeds increase, it is doubtful if any air traffic control system will be able to ensure complete freedom from risk of collision. The development of a reliable collision warning device is urgently required ; it must be able to detect aircraft which constitute a possible danger in time for the relative motions to be analysed and only those which may cause risk of collision should be brought to the pilot's attention. Ideally, the system should search the surrounding air space and, in the light of the information obtained and the " rule of the road " should indicate clearly to the pilot the action required to be taken to avoid risk of collision. Already visual warning even in good weather is inadequate, and until a reliable warning system, at least, is available the hazard of collision will increase as the new big jets come into service. The problem is to provide a system with sufficient coverage without an unacceptable weight and space penalty. Various passive systems dependent on infra red radiation from engines have been tried but so far with very limited success.

Airborne radars can make some contribution to the collision warning problem but it is exceedingly difficult to arrange for them to cover more than a small arc ; however, this can most easily be the forward sector in association with cloud warning equipment and will give a useful measure of protection. The greatest need is for adequate display of the information and an analyser to detect the potentially dangerous aircraft.

This is not the place to discuss air traffic control problems in any detail but there is one development in this field which may in the future become part of a reliable collision warning system. Usually separate radars are used for surveillance and for tracking individual aircraft while they are guided to the final approach point. The development of track-while-scan radar attempts to combine both these functions into one system. As the radar searches the sky electronic gating techniques are used to examine a selected volume of air space about a particular echo during each scan of the system. Repositioning the tracking gates at each scan enables the volume around the predicted position of the echo to be examined and so enables the relative velocity to be extracted. This repositioning is accomplished by computers and the number of aircraft which can be tracked is dependent on the number of computer channels. A similar system might well be developed for airborne collision warning radar.

Development will continue of higher and higher powered radar equipment both for aircraft and missiles combined with even smaller and lighter components. At present the necessity to have large ratios of dish diameter to wave length to achieve narrow beams of high intensity to some extent limits the value of further microminiaturisation for high performance radar equipment. Any developments to overcome this limitation such as electrically steered beams would be of great value.

Nevertheless, development will continue of devices capable of producing higher powers at higher frequencies. Probably the magnetron has nearly reached the end of its development. It is, however, likely to remain the simplest device for the production of high power beams of microwave frequency, and its use will continue for a long time in airborne equipment where frequency shifting is not required. Where this is a requirement for such reasons as security or electrical beam switching, the amplifying klystron will take its place.

More Advanced Problems

No survey of this kind would be complete without reference to the contribution which electrical techniques are making to the solution of the more advanced problems and ideas which are being actively tackled at this time. On the fringe of the subject under discussion is the whole field of gyroscopes, accelerometers, and other devices used in inertial navigation systems. In addition to work on low friction bearings using conventional principles, investigations have been under way for a number of years into radically different designs of gyroscope, such as gymbal-less gyros in which the rotor is supported without mechanical contact by means of magnetic or electrostatic forces. A charged body in a static electric field, or a magnetised body in a static field, has no stable equilibrium position, and in a gyro using this method of support some form of pick off is necessary to detect both rotor position and attitude of the gyro case relative to the stable platform. Of particular interest in the magnetic suspension type is the cryogenic gyro which makes use of the property of super-conduction in certain materials at very low temperatures ; the rotor is repelled by, and thus can be supported by magnetic fields without the need for servo control. The virtual elimination of frictional torque in magnetic and electrostatic gyros leads to very low drift rates. A practical difficulty, however, is that the associated equipment for servo control or super cooling is considerable, while in the electrostatic gyro it is the very smallness of the supporting force which leads to mechanical problems.

An even more advanced idea is the particle gyro making use of the angular momentum of rotating particles. The particle gyro at first sight looks very attractive in that it may be purely electronic. So far, however, this device appears to have progressed only as far as the intitial research stage and there are many difficulties to be overcome. There is no doubt that some of these developments will make rapid progress during the next ten years, making available gyros with very small drift rates suitable for inertia navigation systems in vehicles with long times of flight, such as aircraft and space vehicles. There will also be further progress towards miniaturisation of both gyros and accelerometers. With regard to the latter, there are some interesting possibilities using the vibrating string principle with electrical pick offs or the piezo electric effect in crystals, but at present the problems of stable operation in a changing environment have not yet been solved. An important objective of these developments is to produce an output proportional to acceleration in a form suitable for digital processing. Another approach to this is the pulsed current balance accelerometer, the success of which is dependent on the production of accurately repeatable current pulses at varying frequency.

A considerable amount of study has already been made of devices for converting heat radiation energy and energy from radioactive isotopes directly to electricity. While at present confined to use in the more exotic forms of space vehicles, within the next decade they are likely to be applied to earth-bound aeronautics. In particular, considerable work is going into thermo-electric generation which could lead ultimately to an aircraft obtaining electric power directly from a hot gas source with very few rotating elements. It seems likely that such power would be fairly low-voltage d.c. and static

conversion devices based on transistors and diodes would be required to provide power in an acceptable form. Nuclear auxiliary power units have been under investigation by the American Atomic Energy Commission for a number of years. The Martin Company of Baltimore has built such a unit called Snap 1 which develops 125W at 28V, based on cerium-144. Owing to the shielding required the power weight ratio is very low (1W per pound). It is reported that a 30kW unit should be ready within five years. Basically high energy/weight ratios are available for nuclear fuels of the order of 1000kWL per pound compared to 1 or 2kWL per pound for conventional fuels, but owing to practical problems of shielding, temperature of operation and overall efficiency of conversion it seems unlikely that nuclear power sources will be used in aircraft for a long time, though they may have an application in space vehicles with very long "flight times."

Much work has been done over the past few years on fuel cells in which electrical energy is produced direct from chemical fuels such as hydrogen and oxygen. The primary advantage of this source of energy is the high operating efficiency obtainable, and a refined fuel cell of this type could have great value in airborne applications particularly for space vehicles. At present power/weight ratios are low but with development these are likely to be increased making this source of power a practical and useful proposition.

Solar radiation power is already being used in satellites. With solar radiation density of 1·25kW per square metre in space, it should be practicable to achieve outputs of 100W to 150W per square metre using silicon cells of some 15 per cent efficiency and later 250W with indium antimonide cells of 25 per cent efficiency.

There are two other possible methods of airborne power generation which are at present only in the very earliest stages. These are "flame generation" which relies on the fact that there is an area on the edge of high temperature flames which contains a high proportion of charged particles. The second method depends on the principles of magnetohydrodynamics, using the flow of a conducting liquid in a powerful magnetic field.

Conclusions

But all this is looking fairly far into the future and we must not let these dreams occupy our minds to such an extent that we forget the importance of our bread and butter business during the next five years. During this time the search for weight and space saving, for economy, and above all for greater reliability of electrical and electronic systems, will continue unabated. Inevitably complication will increase with the greater demands that we make on aeronautical vehicles of all types, and the more complex the systems which we install in aircraft, missiles and ultimately space vehicles, the greater is the necessity to concentrate on reliability. This is not only for economic reasons, but also because the more functions which are carried out by electrical devices, the more dependent we are upon them for safety of the vehicles as a whole.

So I believe that one of the most important developments of the next few years, apart from the search for greater reliability itself, is the development of comprehensive testing arrangements for all the electrical and other devices. Much has already been done in this direction for missiles and the experience should be used in aircraft to provide overall testing arrangements which will both detect a fault and diagnose the cause. This must be achieved without wholesale breaking of connections which is in itself such a frequent cause of unserviceability.

As more and more new inventions are produced it is becoming clear that unless there is substantial co-operative effort in the western world, it will be very difficult for us to maintain our competitive position against Russia and other countries which are fast developing the techniques which have been our preserve in the past. Even America will not be able to do everything which is necessary by herself, and I am convinced that the more we can get together by technical exchange agreements and such types of co-operation with American and European Companies, particularly in the field of component development, the better it will be for all of us.

Tanker Cleaning Berth at Birkenhead

A new tanker cleaning installation was brought into use at Rock Ferry, Birkenhead, last week, when the Shell tanker "Hyria" began dischanging oily ballast prior to undergoing repair. The installation is managed by Mersey Tanker Services, Ltd., on behalf of Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., and Grayson Rollo and Clover Docks, Ltd., who together own the whole of the share capital. Facilities are provided at Rock Ferry for gas freeing and tank cleaning prior to repair or maintenance work, or when the grade of oil carried is to be changed. Cleaning of oil fuel tanks in vessels other than tankers can also be carried out, and a complete service is provided to enable shipowners to comply with the requirements of the Oil in Navigable Waters Act, 1955, under which the discharging of oily residue to coastal waters is an offence.

The installation consists of a jetty, built on the site of a former public ferry, and capable of berthing "light" tankers of up to 70,000 tons deadweight; and a shore installation to which the oily residues are pumped for treatment. There are six mooring dolphins and the jetty head itself, which is 276ft long, is formed of two tubular steel strong points set in "Colcrete" foundations on the rock of the river bed and anchored to the rock with McAlloy high-tensile steel bars. A welded plate girder bridge connects the strong points and a 3-ton portal crane runs on rails on this bridge to enable minor repairs to be carried out on a vessel moored to the jetty.

Oily water is pumped to the shore installation where it passes through separators, the oil being processed and burnt in the installation boilers, while the water is returned to the river. There are two Dorr-Oliver separators, with double-acting rakes; these skim off the oil as they travel in one direction, and during the return stroke scrape off any solids which may have settled on the bottom of the separator tank. Together the separators will deal with 900 tons of oily water an hour.

A certain amount of water remains with the oil skimmed off by the separators, and a further gravity separation is carried out to remove this water. The oil is then heated in the tanks to drive off the lighter volatile fractions and raise the flash point of the oil so that it can be burnt safely in the installation boilers.

Oily ballast water, pumped along the jetty by the ship's own pumps, is dealt with first, and then the tank cleaning operation proper is started. For this purpose river water is pumped from the jetty head to the shore installation by means of submersible pumps. Ashore, the pressure of the water is raised by high-pressure boosting pumps, and the water is heated in salt water heaters in the boiler house. The hot, high-pressure salt water is then returned to the jetty head and fed by means of flexible hoses to "Butterworth" tank washing machines inserted in the ship's tanks. The tank washings are returned to the shore installation and treated in the separators in the same way as the ballast water. After mechanical washing the tanks may contain solids which are not pumpable, and have to be cleaned off manually. These solids are treated in a special plant in the shore installation, where steam jets are used to break up and extract any oil which may be present, leaving the dry solids to be disposed of by tipping outside the installation.

A complete oil tank cleaning service is provided at the Rock Ferry installation

SHORTER REPORTS

Automatic Warning System in Southern Region

THE second length of Automatic Warning System train control in the Southern Region of British Railways came into use on November 18. It has been installed on 33 route-miles between Salisbury and Worting Junction (near Basingstoke), extending the system fitted between Exeter and Salisbury in March this year. Track magnets and equipment have been installed at thirty-three distant signals on the main line and on branch lines leading on to it. The system is being installed from Exeter and Bournemouth West to Waterloo. Further stages are planned as follows : Bournemouth West to Southampton Central by June next year ; Southampton to Basingstoke by the end of next year ; and Basingstoke to Waterloo by the second half of 1962.

The system has been given priority on the Western section main line because it is most valuable on fast main lines and the need is greater there than on the Central and South Eastern main lines, which are largely covered by colour-light signalling. It has, however, also been adapted for operation on electrified routes and is being given extensive field trials on the Kent Coast lines.

Post Office Telecommunications Services

ALTHOUGH the telegraph service of the General Post Office showed a deficit of £2,400,000 in the year ended March 31, 1960, the report accompanying the Post Office Commercial Accounts for that period (H.M. Stationery Office, Price 3s.) states that the drop in the number of ordinary inland telegrams was less than in the previous year. The 1959–60 figure of 13,827,000 telegrams in this category was only 1·8 per cent below that for 1958–59, which year saw a fall of 7·5 per cent compared with the preceding twelve months. Telex subscribers increased by some 18 per cent, and nine new automatic telex exchanges were opened. Operators of nine European countries were able to dial calls directly to subscribers on automatic telex exchanges in this country.

The number of telephone calls made was 4189 million, an increase of 143 million on the previous year. The greatest increase of traffic was in the long-distance services. Telephone calls with ships at sea handled by Post Office coast radio stations numbered 116,000, or 11,000 more than in 1958–59.

An increase of 324,000 during the year in the number of telephones in service was more than 50 per cent higher than the increase in 1958–59, and for the first time a substantial reduction was made in the number of subscribers connected to manually-operated exchanges. This fell from 1,000,000 to about 960,000. The number of such exchanges was reduced from 1027 to 921. This is part of the plan to mechanise all exchanges by 1970. Subscriber trunk dialling was introduced at three exchanges during the year, and installation of equipment began at ninety places.

Oil Tanker Fitted With Stabilisers

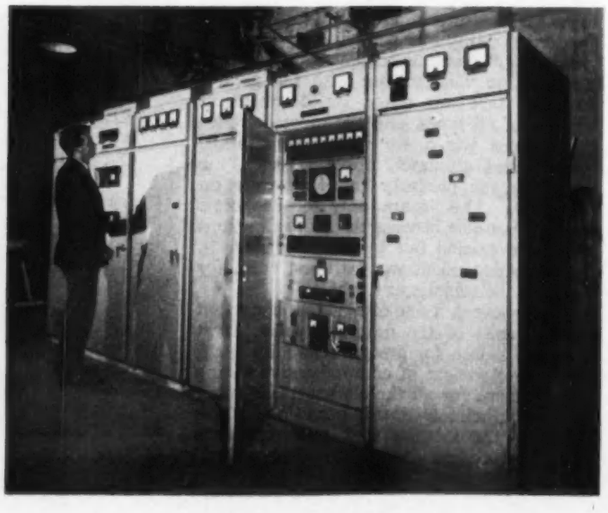
THE oil tanker " J. Paul Getty," presently completing at the Ateliers et Chantiers de France, has been equipped with a set of Denny-Brown stabilisers and preliminary trials were carried out last month when the ship was force rolled and the predicted performance obtained. Later further trails were completed under rough weather conditions and the ship's roll was reduced by the amount expected. The tanker has a displacement of 97,000 tons and carries a deadweight of 73,800 tons on the following dimensions : length between perpendiculars 808ft 4in, breadth moulded 110ft 1in, depth 61ft 4in, and load draught 45ft 4½in. A speed of about 17 knots is maintained by a set of single reduction geared Parsons turbines developing 22,300 normal s.h.p. The stabiliser unit is the largest manufactured to date and each fin has an area of 150 square feet and power is supplied by two size 50 V.S.G. pumps with rotary servo control, the servo pressure being supplied by two size 6 V.S.G. pumps driven by the same motor. Each power unit is driven by a 60 h.p. motor. The equipment is mounted on the double bottom amidships in the permanent ballast tanks and has been fitted on an experimental basis with the object of reducing hull stresses due to heavy rolling, either in loaded or ballast conditions.

Television Transmitters for Canada

WE illustrate one of the two 18kW Band III vision transmitters which, with two 9kW sound transmitters, are being supplied by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex, for new commercial television stations in Montreal. The complete transmitter consists of two air-cooled, three-cubicle units, one comprising a self-contained 4kW transmitter with drive, frequency-trebler and three r.f. stages the last of which is grid-modulated; and the other housing an additional single-stage amplifier to provide 18kW output. The latter employs special circuits to prevent " ghosting " by the radiation of delayed signals, such as might be caused by reflected waves set up by a mismatch due to snow and ice on the aerial system. Both sets of cubicles are designed so that no trenches or sub-floor ducting are required for their installation.

The " anti-ghosting " characteristics of the final amplifier are obtained by the design of circuit. This employs two grounded-grid triodes in Class B, arranged to operate independently, with a 90 deg. phase displacement between them. The cathode circuits in each case consist of a very broad band network which requires no tuning. Both valves are fed from a common input via an " H "-line hybrid which produces the 90 deg. phase change. Approximately maximally flat pair anode tuned circuits are used separately for each valve. A common output is obtained by the use of another " H "-line hybrid which cancels the 90 deg. phase shift in the forward direction but gives a 180 deg. phase shift to reflected power. This arrangement has the property of absorbing any reflected wave coming from the aerial/feeder system.

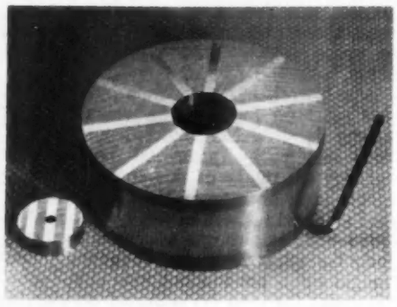
[Reply Card No. E9024]



18kW television transmitter comprising 4kW drive unit (three right-hand cubicles) and final amplifier with mismatch correction circuit

Permanent Magnet Chuck

A PERMANENT magnet circular chuck now made under the trade name of " Fimax " by Darwins, Ltd., Tinsley, Sheffield, is illustrated below. It is available in five sizes from 6in to 24in diameter, each consisting of a manganese bronze body with radial poles. An adaptor plug is screwed in the centre of the chuck by a cap screw and can be removed to enable the drilling, boring and internal grinding of components at one setting. When fixed in position the adaptor ensures that the magnetic flux extends over the full chuck face area.



Permanent magnet chuck with removable central adaptor plug

The removal of the plug enables spigoted workpieces to be set concentric using non-magnetic bushes in the bore, or ready bored pieces with the fitting of a stub mandrel.

[Reply Card No. E9025]

Domestic Heat Pump

WE are advised by Jonmil Building Developments, Ltd., that its domestic heat pump has now been installed in a show house at Caversham, Berks. The pump, running on a methane-base fluid, takes heat from the larder, which is provided with an ice-maker, and disperses it in central heating—i.e. the efflux from a single air-cooled heat exchanger can be ducted to any room it is desired to warm. A supplementary heat source comprising a 3kW resistance heater is selected by the thermostat in cold weather. A water heater is an optional extra. The coefficient of performance is of the order of four (three as a refrigerator).

[Reply Card No. E9026]

Towed Target Systems

"RADOP" (Radar/Optical) towed target systems, as supplied by the Del Mar Engineering Laboratories of Los Angeles, California, to the Royal Canadian, Royal Belgian, and United States Air Forces and the United States Navy are to be marketed in Great Britain and the Commonwealth and most of Europe, Africa, and the Middle East by Fairey Engineering, Ltd. Installation, training and support will be undertaken by the British firm, manufacture remaining with the original source.

This target system is designed to provide targets with a performance similar to that of the interceptor and to be employed by an operational unit rather than a specialist squadron. The towing gear consists of a windmill-driven reel and a launcher, designed to be carried on the bomb or tank shackles of an aircraft. There are two kinds of targets, both being wingless darts, the DF-4 for subsonic speeds and the DF-6 for speeds up to M. 1·5. They are towed on piano wire of 0·033in up to 0·05in diameter and up to 6½ miles long. The subsonic dart is 8ft long and shaped like a classical bomb ; it is made of resin-bonded fibre and contains a set of aluminium-coated foamed plastic planes forming 90 deg. corner reflectors and giving a radar response equivalent to that of a large aircraft. An optional addition, necessary if infra-red passive homers like "Sidewinder" and "Firestreak" are to be fired at the target, is a set of four flares at the tail ; a u.h.f. or v.h.f. receiver must be added to the dart to receive the command to ignite the flares.

The supersonic dart is 11ft long and is towed by a probe projecting from its nose. To allow the attacking pilots to find it in daylight, it has a visual augmentation unit comprising two discs, each of twelve cartridges containing fluorescent powder ; on a radio command, the twelve cartridges explode over a period of one minute, producing a puff of fluorescent smoke. (This visual augmentation unit can also be included in the radio-equipped DF-4.) For the supersonic targets a combined reel and launcher is used, and the assembly can be rotated about its axis (see accompanying illustration) to bring the launcher clear of the ground when taxi-ing and well away from the wing when launching or recovering a target.

For exercise with ballistic rockets or aimed missiles such as the Fairey "Fireflash," a scorer can be carried on the attacking aircraft which may either be self-contained (with its own X-band radar) or use the existing range-finding "radar." In either case a 16mm cine-camera records on the same frames both the "bore sight" view and the range display of the radar. The blips representing missile and target will be seen to converge, merge, and then diverge, and in the frame where they coincide it should be possible see the images of both target and missile. Assuming the missile speed to be much greater than that of the target, this frame will show the nearest approach to collision, and the miss distance can be estimated either by calibrating the range display or by comparison with the size of the image of the target.

It is reported that the Ministry of Aviation are soon to perform trials of "Radop" equipment for the Royal Navy and Royal Air Force. Since it would appear improbable that a reel-launcher could be attached to a "Lightning," these will presumably be confined to the DF-4 target.

[Reply Card No. E9031]

Inspection of Pressure Plant for Land-Based Nuclear Installations

RECOMMENDATIONS for the design, manufacture and testing of pressure components of land-based nuclear installations have been published by Lloyd's Register of Shipping.

The Society, through its Land Division, has been closely associated with the survey and inspection of such pressure components from the early stages of the development of nuclear power in the United Kingdom. During this time Lloyd's Register has undertaken the inspection of the pressure plant of the Calder Hall and Chapelcross power stations, and now has similar responsibilities for five civil nuclear power stations, which are now under construction in this country, in Italy and Japan. The Society is also similarly engaged on prototype installations such as the advanced gas cooled reactor (A.G.R.) being built at Windscale for the United Kingdom Atomic Energy Authority, and the "Dragon" project which is being built at Winfrith under the auspices of the Organisation for European Economic Co-operation. On the development of reactor installations suitable for marine nuclear propulsion the Society recently published "Provisional Rules for the Classification of Nuclear Ships."

In 1957, for the guidance of manufacturers, the Society published preliminary notes containing recommendations for the design and construction of the primary-circuit pressure components of gas-cooled graphite-moderated land-based reactors to be built in the United Kingdom under the Society's Survey. In the new publication these notes have been revised in the light of experience gained and are now presented in a comprehensive and up-to-date form to cover the nuclear reactor systems now being built or projected. It is intended to review and supplement these recommendations as further experience is gained.

In this publication, pressure vessels and components for nuclear service are grouped in four categories.

Category "A" covers pressure vessels and components which are intended to contain radioactive materials and are subject to neutron irradiation such that the physical properties of the constructional materials will be affected during the projected life of the installation. It also includes items which, because of the biological effects of radioactivity will be inaccessible for comprehensive periodic examination and maintenance.

Category "B" covers pressure vessels and components which are not subject to neutron irradiation, are intended to contain radioactive materials in service but which on shut down will be accessible for full examination at any time during the projected life of the installation.

Category "C" covers pressure vessels and components which will not contain radioactive materials, nor be subject to neutron irradiation and will be accessible for full examination and maintenance throughout the projected life.

Category "D" caters for emergency containment vessels.

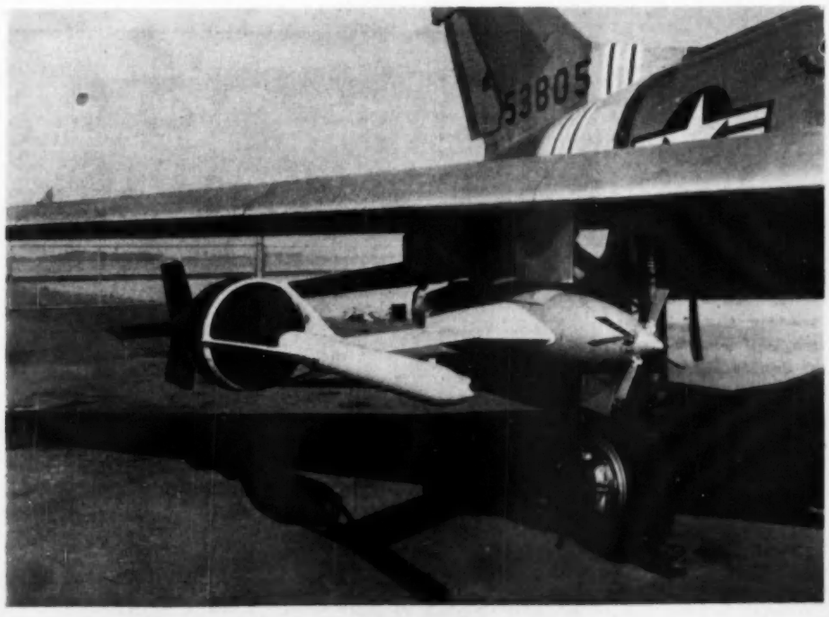
In each category requirements are given for design, materials of construction, fabrication procedure (including non-destructive examination, and production tests) workmanship and testing. There are four appendices dealing, respectively, with : primary circuit over-pressure relief systems ; ultrasonic examination of materials ; plate pressing procedure and production tests ; and weld procedure and operator tests.

Copies of the publication, *Survey of Pressure Components for Land Based Nuclear Installations —Provisional Requirements* 1960 (price three guineas) can be obtained from Lloyd's Register of Shipping, Land Division, Norfolk House, Croydon, Surrey.

Tunnel Diodes in Production

FOUR tunnel diodes of the 1N650 series are claimed by Texas Instruments, Ltd., Dallas Road, Bedford, to be the first commercially available gallium arsenide semiconductor devices in the world. This range, now in full production, offers peak currents up to 10mA ±2 per cent, large voltage swings, very high peak to valley ratios (greater than 15 to 1), forward voltages up to 1·1V ±5 per cent and high-temperature operation (up to 150 deg. Cent.). They will operate at frequencies of at least 500 Mc/s. These diodes are designed for specific applications in high-speed computer circuitry such as logic circuits, amplifiers and oscillators, and for general computer purposes. All four devices are housed in a lightweight subminiature case. Work is now in progress designed to extend the tunnel diode principle to a complete family of semiconductors to match continuing advances in computer circuitry.

[Reply Card No. E9033]



Reel-launcher combination on a North American "Super Sabre" ; to stream the target, the pylon is rotated down to the vertical

Enlarged view of gallium arsenide tunnel diode in lightweight subminiature case

SHORTER REPORTS *(Continued)*

Cynheidre colliery surface installations under construction

Cynheidre Colliery

WHAT is considered to be one of the largest and most complex projects undertaken by the National Coal Board, the Cynheidre colliery, was officially commissioned on Thursday last, November 17. This Cynheidre project is situated some 5 miles north of Llanelly overlooking the Gwendreath Valley and is in the No. 1 (Swansea) area of the South Western Division of the N.C.B. The anthracite reserves in this area are contained in eight seams all of which are being or have been worked in the older collieries which are to be replaced by the new scheme. The coalfield itself presents severe geological problems, due to strata disturbance resulting from faulting and folding, and these conditions have been one of the factors leading to the decision to introduce the horizon mining system for the project. It is expected that when fully developed the new colliery will have an output of 4000 tons of saleable coal a day and all the winding, treatment and other surface plant has been designed to handle this output. The annual production by 1963 will, it is anticipated, be some 2200 tons of coal a day.

Two new concrete lined shafts (Nos. 1 and 2) have been sunk to a depth of approximately 800 yards and an existing shaft (No. 3) some 3½ miles from the main site has been deepened to 160 yards. Preparations are now in hand for sinking a fourth shaft near No. 3 shaft. Under the scheme five pit bottoms have been constructed and 13 miles of tunnels driven. The three horizons which have been driven are at depths of 490 yards, 560 yards and 660 yards and in the first instance coal is being mined in seams between the 560 yard and 660 yard horizons at the main site and the 490 yard and 560 yard horizons at No. 3 site.

Coal-face mechanisation is being extensively used and two coal ploughs are at present in operation, whilst plans for introducing others have been prepared. Coal loaded by the ploughs on to armoured conveyors is transferred on to belt conveyors for transport to central stations where it is loaded into mine cars. The trains of cars are hauled by diesel locomotives to the shaft bottom where the cars are handled by spotting creepers and pneumatic rams into the winding cages.

At the main site, to be seen in our illustration, No. 2 shaft tower winder has been completed and No. 1 is in an advanced state of completion. These two friction winders are of continental design and are the first to be installed in the South Western Division of the N.C.B. When No. 1 shaft winder is completed it will have a three-deck cage to carry twelve mine cars with a total payload of 18 tons. No. 2 shaft will be used for service purposes handling stone and materials.

Initially No. 3 shaft is being used for man-riding and development purposes and it will eventually be used for materials. The No. 4 shaft to be sunk later will provide man-riding facilities and for ventilation requirements. Ventilating fans installed at No. 2 and No. 3 shafts will, when fully developed, deliver some 840,000 cubic feet of air a minute into the workings. Compressed air for underground plant is to be supplied by two compressors at the main site and three at No. 3 shaft, each machine being designed to deliver 5000 cubic feet of air per minute.

A point of interest in connection with the winding equipment at the main site is the introduction of push-button operation for the materials winding sequence and automatic equipment for operating the mine car system. For man-riding purposes the push-button control gear can be switched over to manual control.

A coal preparation plant has been laid down at the main site and is equipped to prepare coal in five graded sizes for the market as well as ¼in–0in washed duff. This plant is designed for a throughput of 400 tons an hour and during the period it will take for the new mine to attain its full production the installation will be used as a central washery for the Gwendreath Valley collieries.

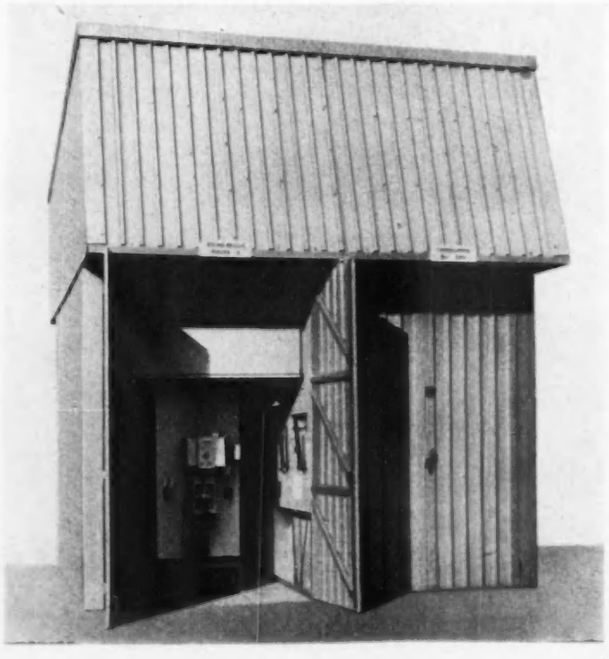
"Packaged" Weatherproof Switching Station

WE illustrate a new "packaged" outdoor switching station produced by The English Electric Company, Ltd., Strand, London, W.C.2. This self-contained 33kV unit, known as the "Weatherbeater" is designed to occupy little more space than a conventional indoor installation and less than a normal outdoor station. The associated civil engineering costs are low, as the unit needs only a simple concrete raft foundation. No building is necessary; the exterior weatherproof housing is of aluminium, which needs no painting or periodic maintenance.

A switching station is built from standard units, each 16ft 9in high by 12ft 3in deep. The width is 6ft 6in to house 1200A equipment and 7ft 3in to house 1600A to 2000A equipment. Each unit houses either an English Electric "OKM4" or "OKM5" single-tank oil circuit breaker for current ratings up to 1200A and 2000A respectively. It is available in single-busbar form for short-circuit ratings of 750MVA and 1000MVA.

Isolation is by hand-operated isolators on both sides of the circuit breaker. Built-in cable equipment and, where required, busbar earthing equipment are included, as well as hand-operated safety shutters. The usual interlocks associated with metalclad gear are provided. All isolators, earthing equipment and shutters are operated from a single control point mounted on the side of each unit.

[Reply Card No. E9042]



"Weatherbeater" outdoor switching station housing two 33kV feeder units in an aluminium weatherproof enclosure

Transistorised Single-Sideband Radio

WITH a fully-tropical specification and a weight of 37 lb, the Redifon GR.410 single-sideband transmitter-receiver illustrated is aimed at meeting medium-range communications requirements in all parts of the world for public services and commercial undertakings. The equipment, covering the range 3 to 18 Mc/s, has a p.e.p. of 100W and can be used as a fixed or mobile station. All stages are transistorised except the driver and power amplifier in the transmitter. Power supplies are taken from interchangeable units operating from 12V or 24V d.c. inputs or from a.c. mains. The services provided are c.w. and m.c.w. telegraphy, and a.m. telephony, on eight channels, using upper and lower sidebands of four crystal-controlled spot frequencies. Essential operating controls are mounted on the "L"-shaped sub-unit seen on the front panel in the illustration, which can be detached and fitted to a mounting panel in an alternative operating position, being connected to the main equipment by a plug-in cableform. Full remote control is available over a distance of up to 100 yards by use of a similar cableform and a separate remote control unit measuring 8¾in by 4¼in by 3½in which includes channel and service selection by means of uniselector drive.

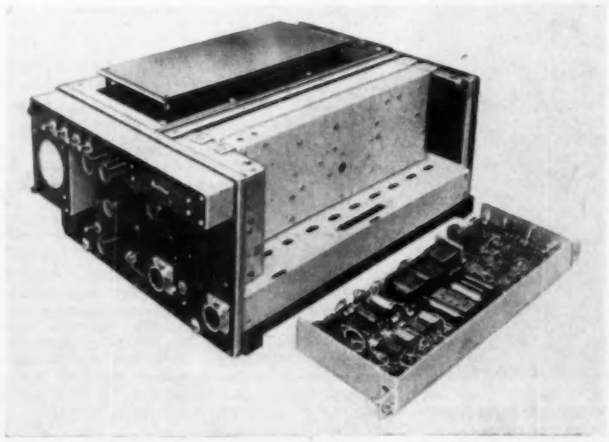
The system of single-sideband modulation and demodulation used in this equipment is known as the "third method," to distinguish it from the filter and out-phasing methods, in both of which the carrier and unwanted sideband are generated but balanced and filtered out. In the "third method" the nominal carrier is not generated, but a true single-sideband signal with fully-suppressed carrier is produced by combining the outputs of two modulator chains and is mixed with the output of an oscillator operating on the appropriate radio frequency to produce the desired r.f. drive for the power amplifier.

The receiver section of the GR.410 is completely transistorised. The r.f. amplifier stage is mounted on the main chassis, together with the local oscillator (which is also the channel oscillator on transmit). Frequency control is accurate to within 0·0005 per cent. For a 10bB signal-to-noise ratio on s.s.b. operation, sensitivity is better than one microvolt. Audio output is 500mW to the built-in loudspeaker, and 2W to a 3 ohm external loudspeaker.

The transmitter employs transistors for the oscillator and buffer amplifier, and valves for the driver and p.a. stages, the latter comprising beam tetrodes connected in parallel feeding a pi-network output circuit of 75 ohms impedance. Output power rating on s.s.b. with fully suppressed carrier (A3a) is 100W peak envelope power. For c.w. telegraphy the output is 50W, and for telephony (A3) which in this case is compatible a.m., the output is 25W carrier plus 25W sideband.

In the accompanying illustration the s.s.b. generator-demodulator unit is seen unplugged from the main chassis. The receiver i.f. amplifier and the audio unit are of similar construction and are shown in position.

[Reply Card No. E9051]



Transmitter-receiver for h.f. single-sideband working, showing the plug-in form of circuit units

Automatic Water Sampler

A FULLY automatic water sampler based on original work carried out at the Water Pollution Research Laboratory and manufactured under licence from the N.R.D.C. is now being made by Elcontrol, Ltd.

The sampler consists of a self-contained unit with twelve 20 ounce sample bottles. Each bottle is sealed by an airtight plug through which passes a rubber tube connected to an outlet. All the outlets are accessible on a panel; bottles and outlets are numbered for the purpose of easy identification.

The rubber tube from each sample bottle is controlled by a magnetic pinch valve. Each pinch valve can be manually closed and subsequently re-opened electro-magnetically. The magnetic pinch valve is closed manually and retained by a permanent magnet. It is re-opened by a pulse from the power supply via the stepping relay which opposes and overcomes the pull of the permanent magnet.

To prepare for a sampling sequence, each sampling bottle is first evacuated, using an external vacuum pump, by connecting each outlet in turn to the vacuum pump and switching open the relevant magnetic pinch valve, there being twelve switches mounted in the unit above their respective sample bottles. When this preliminary evacuation has been completed the manual switches are closed in turn, retaining the vacuum in the bottle, and the external pump is then disconnected.

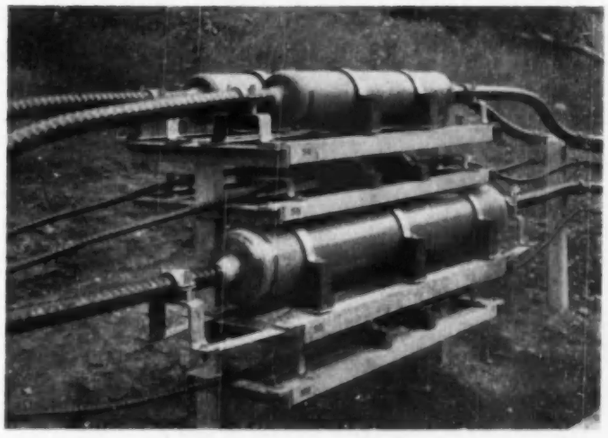
The unit contains in addition to the sample bottles, associated tubing and pinch valves, a fifteen-day clockwork motor and a transistorised power pack, driven by a 6V battery. The pinch valves are automatically opened at predetermined intervals controlled by the clock. The time clock actuates a microswitch at each interval and at each operation a condenser is discharged through the coil of the stepping rotary switch advancing selection by one position. This at the same time causes the coil of the pinch valve to receive a pulse thus releasing the valve of the selected sampling bottle and causing a sample of the liquid under examination to be driven into the bottle.

The complete unit measures 24in long by 15in high by 10in wide. A control panel carries the following controls: (1) Sample period selector (providing for one sample every one, two or four hours). (2) The manual winder for the clockwork motor. (3) A switch which initiates the sampling cycle.

[Reply Card No. E9052]

Railway Electrification Cable

THE connection from Shenfield grid substation to the nearby 6·25kV feeder station for the British Railways, Eastern Region, 50 c/s electrified line to Southend (Victoria) is made by oil-filled, aluminium-sheathed cable. Conversion of this line at the beginning of November from 1500V d.c. to the British Railways high-voltage a.c. system was described in our November 11 issue.



Joints in the corrugated seamless aluminium cable route from Shenfield grid substation to the railway feeder station

To effect the connection with the grid at Shenfield, the British Insulated Callender's Cables Group manufactured and installed 1800 yards route length of double circuit 0·85 square inch, 25kV/earth concentric oil-filled cable of the corrugated seamless aluminium (C.S.A.) sheathed pattern. The resistance of aluminium to vibration fatigue makes aluminium-sheathed cables particularly suitable for railway work, whilst the reduced weight and high flexibility of a C.S.A. cable has advantages for all forms of installation. As a result of the reduced sheath wall thickness which the corrugated technique permits, cable costs are reduced and the economics of a project are automatically altered. Protection against corrosion of the aluminium sheath is provided by means of an extruded p.v.c. outer serving, the integrity of which is tested electrically after manufacture and following installation.

The major portion of the cable route, a section of which is illustrated, showing straight-through joints, follows the railway track, the cables running above ground on concrete posts. The mechanical strength and reduced weight of the cable permitted the supports to be spaced at 15ft intervals, thereby further reducing installation costs.

In the accompanying illustration the two upper cables form the 25kV double circuit. The lower cable is a three-core 33kV 0·35 square inch copper conductor oil-filled cable with C.S.A. sheath, served with p.v.c. The pilot cables for both cable routes are also seen.

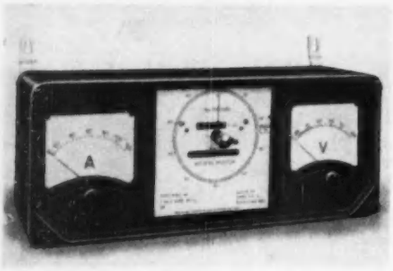
[Reply Card No. E9053]

SHORTER REPORTS *(Continued)*

Arc Welding Equipment

DURING the past week an exhibition of arc welding equipment, electrodes and accessories has been held in Kensington Court sub-station by the welding division of The English Electric Company Ltd., English Electric House, Strand, London, S.W.1. Amongst the equipment being demonstrated is the firm's LWAD plant which, by switch selection, gives a.c. or d.c. output and can be used in addition to metal arc welding as a power source for inert gas welding processes. These plants are stated to be particularly suited for use in underdeveloped areas, where trained maintenance staff is not readily available, as the static power source contains no moving parts calling for regular service attention. All equipments in this range are oil cooled and their cooled silicon diode rectifiers as designed to operate at temperatures up to 190 deg. Cent. The multi-operator sets available with or without built-in power factor correction capacitors can be used by up to eighteen welders.

A new product of the company is a meter for a.c. welding protection, which being designed to measure the electrical conditions in a welding arc, can be applied in costing, calculating



Meter for measuring the electrical conditions in a welding arc

efficiency, developing electrodes and improving production techniques, such as determining the ideal cooling rate for various metals. The unit to be seen in our illustration, consists of a watt-hour meter, ammeter, voltmeter and protective relay all housed in a compact case, suitable for switchboard or wall mounting. With it the user can see at a glance the arc voltage and current and the total energy being consumed. The relay, which is reset by a push-rod on the underside of the case, is incorporated to give protection against overcurrent in the event of the meter being used with an incorrect current transformer ratio. A four-range current transformer for stepping down the current from 100A, 300A, 500A or 1000A to 5A which can be supplied gives a wide variation of the welding currents that can be accurately recorded.

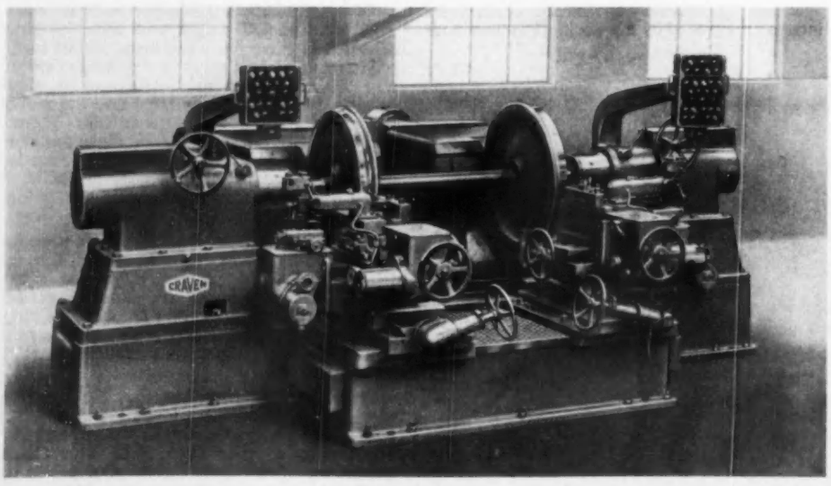
The watt-hour meter has a pointer which moves over a 4in diameter scale, one revolution of the pointer being equivalent to 100Wh at 100/5A; for other ratios a multiplying constant must be used. The pointer can be reset to zero after each welding operation by depressing a knob in the meter glass and turning it anti-clockwise. The total watt-hours are shown on a counter in the meter. The ammeter and voltmeter are of the 4in square moving iron pattern and zero adjusters are accessible through cover plates in the meter window. The voltmeter is scaled 0-120V and is marked 1V per division between 20V and 45V, the normal arc voltage range. The ammeter is scaled 0 to 120A and read direct for a current transformer ratio of 100/5A.

The twenty-six different electrodes shown include the new "Super-Stainless" electrode for high-speed welding of stainless steels. It is stated to be capable of depositing some 50 per cent more metal than conventional stainless steel electrodes, which is made possible by providing the electrode with a heavier coating containing metallic powder. This electrode can be used with a d.c. or an a.c. output.

[Reply Card No. E9061]

Railway Wheel Lathe

AN illustration on this page shows a recently introduced railway wheel lathe which has been developed by Craven Brothers (Manchester), Ltd., Reddish, Stockport, for re-turning wheel sets with plain or roller journal bearing boxes in position. On this machine the wheel set is mounted between revolving centres and rotated for the turning operation by a pair of driven friction rollers held against each wheel at the rear by hydraulic pressure, These rollers are tapered to engage the wheel rims at an angle and each pair of rollers is mounted in independent and opposed sliding blocks. The hydraulic pressure applied through the roller blocks provides a balanced thrust sufficient to transmit the driving torque. The saddles for these roller drives are separate units but are advanced in unison to the driving position where they are electrically tripped to maintain a correct relationship between the rollers and the treads.



Friction roller drive lathe for railway wheel sets. This machine incorporates profiling equipment and is made in two sizes to turn wheels from 30in to 48in or 36in to 60in diameter of any gauge

The spacing between each pair of rollers can be adjusted to enable them to drive wheels of different widths. The machine is available in two models to accommodate wheel sets of any rail gauge and take wheels from 30in to 48in or 36in to 60in diameter. The rollers are driven from a 48 h.p. two-to-one commutator motor through a three-speed gearbox giving a range of turning speeds between 50ft and 160ft per minute.

The maker's electrically-operated profile copying equipment is fitted on each of the two tool rests to simultaneously machine the tyre profiles on both wheels. The tool slides have means of transverse adjustment to the required wheel-set rail gauge and are set by gauges to the wheels diameters. Hand adjustment, power feed and quick traverse motions are provided for both the longitudinal and transverse movements of each of the tool slides. The separate variable-speed motors used for the tool slide longitudinal and transverse feed motions are automatically controlled by a tracer head stylus with reference to a master template when turning wheel profiles.

Machines of this design can be arranged for loading with lifting equipment or fitted with tool slides which can be moved outwards by power to enable wheel sets to be rolled in and raised to centre height by built-in jacks.

[Reply Card No. E9062]

Symposium on Experience of Large Scale Industrial Vacuum Plant

THE Institution of Mechanical Engineers announces that, following a recommendation by the Joint British Committee for Vacuum Science and Technology, its Council has agreed to sponsor a symposium of papers on user experience of large-scale industrial vacuum plant. It will be held at the Institution, 1, Birdcage Walk, Westminster, London, S.W.1, on March 1 and 2, 1961.

The main objective of the symposium, the Institution says, is to bring together designers and users of vacuum plant to discuss their problems and techniques. The Joint British Committee feels that both designers and manufacturers would benefit from the opportunity to learn about users' experience with such plant, and that users would welcome the opportunity to place their experience on record.

On Wednesday, March 1, between 4 and 5 p.m., a general review paper will be presented and this will be followed by papers on vacuum processing and treatment of metals. On Thursday, March 2, between 9.30 a.m. and 1 p.m. further papers on metallurgical subjects will be presented, together with a contribution on steam ejection vacuum plant and a paper on capacitor drying. In the afternoon of Thursday, between 2 p.m. and 5 p.m., there will be papers covering medical and food processing aspects. In all, some twelve papers are to be discussed.

Launches and Trial Trips

STUART PRINCE, oil tanker; built by William Doxford and Sons (Shipbuilders), Ltd., for the Prince Line, Ltd.; length between perpendiculars 530ft, breadth moulded 71ft 9in, depth moulded 40ft 1in, deadweight 18,600 tons on 30ft 2in draught, thirty cargo oil tanks, two cargo pump rooms, four 500 tons per hour cargo oil pumps; Doxford oil engine, six cylinders, 650mm diameter by 2320mm combined stroke, service speed 14½ knots. Launch, August 9.

LAGO GENERAL CARRERA, cattle carrier; built by Ateliers Duchesne et Bossière for the Empresa Maritima del Estado; length between perpendiculars 285ft 5in, breadth moulded 40ft, depth to upper deck 21ft 4in, draught loaded 9ft 10½in, deadweight 1100 tons, displacement 2450 tons; two Bipod masts, one 10-ton and four 3-ton derricks, service speed 12 knots; two M.A.N., G.9.V 30/45 supercharged diesel engines, 21,000 total horsepower at 360 r.p.m. Trial, August.

INDUSTRIAL NEWS

The British Motor Corporation

The ninth annual general meeting of The British Motor Corporation, Ltd., is to be held on December 14, at Longbridge Works, Birmingham. In his statement, which has been circulated to all shareholders, Sir Leonard Lord, chairman of the Corporation, says, that he appreciates the vital need for economic curbs and controls. Without them recessions would be slumps. But it is also clear, he adds, that the Government and its economic advisers are not using the experience they have gained in the manipulation of the controls they at present favour. They underestimate the speed with which world conditions change and the time necessary for controls to take effect. The present restrictions, Sir Leonard points out, began with a bank rate increase last January, followed by another in June. In between these came restrictions of hire purchase and of bank advances and liquidity, followed by a reduction in the bank rate in late October. These measures may prove to have been timed too late and to have continued too long, and in his opinion, Sir Leonard says, more careful discrimination in their application is required. The bank rate has to be general, but hire purchase restrictions, he suggests, can be tailored to the products concerned and their immediate prospects.

Sir Leonard goes on to say that another urgent Government responsibility is to define our position in Europe as between the Common Market and the Free Trade Association. A reduction of tariffs between members has already commenced, but the increase of tariffs by some members of the Common Market towards the realisation of the common external tariff to which they are committed has not so far taken place.

It is worthy of comment, Sir Leonard says, that while the motor industries of the Continental countries continue to receive positive help from their Governments in fostering exports, the only assistance we can expect or hope from ours is the tardy relaxation of the trade controls they have previously imposed on us.

Joint Negotiation

The Ministry of Labour has published this week an entirely new edition of its *Directory of Employers' Associations, Trade Unions, Joint Organisations, etc.* The directory contains the title and name and address of the secretary of every organisation in the United Kingdom, known to the Ministry, which is responsible for negotiations or recommendations on wages and working conditions, or is represented on organisations which are so concerned. There are over 2000 of them given in the directory and for easy reference they are separately indexed under employers, employees and joint negotiating machinery. Within each section these organisations are grouped according to the industries in which they function, the groupings following closely those shown in the 1958 Standard Industrial Classification and therefore differing materially from those in earlier editions of the directory. In the trade union section an indication is given of those unions which are affiliated to the Trades Union Congress or the Scottish Trades Union Congress, and those which are registered under the Trade Union Acts.

The new edition of the directory is in loose-leaf form and for an annual fee of five shillings purchasers will be notified approximately every two months of any changes. The directory is available from H.M. Stationery Office, price 21s.

Ford Motor Company, Ltd.

Following the announcement made earlier last week that the Ford Motor Company, Ltd., had received a letter from Ford Motor Company of U.S.A. regarding its intention to make an offer to the shareholders of Ford of England to acquire the minority shares of that company, the terms of the proposed offer have now been discussed with H.M. Treasury. Because of United Kingdom exchange control regulations it is necessary that an offer of this kind be made in sterling and the American company therefore announced on Saturday, November 19, that it intends to make an offer in sterling at 145s. 6d. for each £1 share, subject to the consent of the Treasury being obtained.

On Monday, November 21, Mr. Selwyn Lloyd, Chancellor of the Exchequer, said in the House of Commons that the Government had decided that approval should be given to the proposed transfer of shares if an offer is accepted by the shareholders.

In the American company's statement, released on Saturday, it was said that the major objective in proposing to acquire the minority shares of Ford of England was to obtain greater operational flexibility and to co-ordinate better the American and European operations so that the Ford Group might be able to compete more effectively in world markets. The operations of the Ford Motor Company, Ltd., would continue under the direction of Sir Patrick Hennessy, the statement added, with continuity in its employment policy.

Trade by Air

According to the latest statistics issued by the Board of Trade the total trade by air of the United Kingdom continued to rise during the first half of 1960. Compared with the second half of 1959, imports rose by £11,700,000 or 15 per cent, exports by £7,700,000 or 10 per cent, and re-exports by £3,800,000 or 33 per cent. Compared with the first half of last year the increases were, imports £25,500,000 or 41 per cent, exports £16,800,000 or 25 per cent, and re-exports £2,500,000 or 19 per cent.

The most important exports, the Board states, were in the non-electric machinery group which, compared with the same period in 1959, rose by £9,600,000, an increase of 48 per cent. As in the past, the Board adds, machinery of all kinds constituted a large proportion of all freight by air, being about 46 per cent of the total during the first half of 1960.

Rating and Valuation

The Rating and Valuation Bill, published on Friday, November 18, is mainly concerned with preparing the way for new valuation lists for rating due under existing legislation to come into force on April 1, 1963. The valuation lists in current use came into force on April 1, 1956, and in them, domestic property is fully rated—but on 1939 rental values; shops, offices and most other buildings are rated at 80 per cent of their rental values at the time of the 1956 revaluation and industry and freight transport are rated at 50 per cent of their 1956 rental values.

Clause 1 of the new Bill provides for industry and freight transport to be fully rated when the new lists come into force in 1963, but the Ministry of Housing and Local Government points out that this does not mean that the share of the rates borne by industry will be doubled, because the simultaneous rating at full value of shops, offices, &c., and the rating of houses at current instead of 1939 values will substantially offset any increase in industry's share of the total rate burden. Industry and freight transport had a rateable value after re-rating in 1959 of about £80,000,000, of which over £77,000,000 was industry, some 11½ per cent of the total rateable value for England and Wales.

Part II of the Bill, with the Second and Third Schedules, introduces a formula method for the valuation of statutory water undertakings. These are at present assessed, the Ministry says, by reference to their accounts, and the method tends to produce the highest assessments, proportionately, for undertakings which have incurred heavy capital expenditure since the war. The new formula starts for most undertakings with their values in the present lists at the beginning of November, 1960, although there is to be an initial scaling-down for a small number of undertakings which, in proportion to the water they supply, have assessments more than 75 per cent above the average for all undertakings. Provision is then made for the adjustment of water assessments on the occasion of each general revaluation of other properties. The adjustment will take account both of changes in the amount of water supplied annually and of local changes in the rental values of other properties since the previous revaluation, as measured by their net annual values.

The Answer is Simple

The Mobil Oil Company, Ltd., and Mobil Oil Française have jointly produced a film, entitled in English "The Answer is Simple," to present in a non-technical manner the advantages of the Mobil Economy Service. The essence of this service is that lubricants of sufficiently advanced specifications have an unprecedentedly wide application, and therefore operators of large fleets of varied machinery can effect large savings on administrative expenses.

The lubricants number, in fact, only four. Delvac Special is used in all engines and power hydraulic systems (excluding vehicle brake systems and similar applications); this is an oil to Supplement I and of mixed viscosity, 10W/30, and also contains additives to counter wear in high-speed engines with o.h.v. gear. Mobilube GX90 is used for all enclosed gears.

Mobilgrease MP is used for all grease points, this is a lithium base grease combining water resistance with temperature tolerance, but it may not be suited for hubs with brake discs attached directly to them. Dorcia No. 20 is applied to exposed gears and to wire ropes. The film is in Technicolor and shows a wide variety of animated scenes.

PERSONAL AND BUSINESS

Appointments

MR. F. V. WICKHAM, A.M.I.C.E., has joined the board of directors of Temple Tubes, Ltd.

MR. C. GOSLEY has joined the used machine tool division of E. H. Jones (Machine Tools), Ltd.

LLOYD'S REGISTER OF SHIPPING has appointed Mr. L. D. Trenchard as principal engineer surveyor at Glasgow.

MAVOR AND COULSON, Ltd., announces the appointment of Mr. Robert M. Clive as general sales manager.

MR. W. A. PRINCE has been appointed by Ferodo, Ltd., as the company's manager in the Republic of Ireland.

KEELAVITE HYDRAULICS, Ltd., has announced the appointment of Mr. T. P. Keeling as its European representative.

THOS. P. HEADLAND, Ltd., states that Mr. Frank Smith, A.M.I.Mech.E., has been appointed general sales manager.

MR. A. A. TAYLOR has been appointed company secretary to Sterling Metals, Ltd., in succession to the late Mr. T. Barker.

MR. K. D. VICK, previously the company's London representative, has been appointed to the board of Cranes (Dereham), Ltd.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., has appointed Mr. A. B. Frost the assistant manager of its Midland sales region.

MR. LAURENCE J. FORD, chief development engineer of Stanley Works (G.B.), Ltd., has been appointed chief engineer.

CONSTRUCTORS, Ltd., has announced the appointment of Mr. A. E. Newland to the boards of two of its subsidiary companies, Pratt Brothers, Ltd., and Poles, Ltd.

BRITISH RAILWAYS WESTERN REGION announces the appointment of Mr. W. N. Griffiths as running and maintenance officer, divisional traffic manager's office, Cardiff.

MR. F. BURGESS has been re-elected chairman of the British Valve Manufacturers' Association for the year 1960-61. Mr. K. M. Leach has been re-elected vice-chairman.

MR. P. JARDINE, group financial controller, Metal Industries, Ltd., has been appointed to the boards of two M.I. subsidiaries, J. G. Statter and Co., Ltd., and Minerva Mouldings, Ltd.

RESEARCH AND CONTROL INSTRUMENTS, Ltd., announces that Mr. A. S. D. BARRETT, M.I.Mech.E., M.I.Chem.E., has been appointed consultant to the company and has joined its board of directors.

MR. HAROLD MCCUE, chairman of Taylor Woodrow (Building Exports), Ltd., has been appointed a member of the Building Research Board of the Department of Scientific and Industrial Research.

MR. A. R. M. GEDDES has been appointed as a part-time member of the United Kingdom Atomic Energy Authority for the four-year period November 21, 1960, to November 20, 1964.

MR. C. J. BULLOCK, A.M.I.Gas.E., has been appointed chief chemical engineer of Bennett, Sons and Shears, Ltd., and has taken up his appointment at the company's head office, Pepper Road, Leeds, 10.

LONDON TRANSPORT has announced that Mr. H. W. Hadaway, A.M.I.E.E., has been appointed a principal executive assistant in the signal engineer's department with the title of installation engineer (signals).

MR. FRANK COUSINS has been appointed to be a member of the Council for Scientific and Industrial Research in succession to Mr. H. Douglass who has retired from the Council on completion of his term of service.

THE SKEFKO BALL BEARING COMPANY, Ltd announces that Mr. A. I. Helm, hitherto the company's plant engineer, has been appointed works manager of the company's proposed new factory at Irvine, Ayrshire.

WESTLAND AIRCRAFT, Ltd., announces that Mr. L. Boddington, M.I.Mech.E., F.R.Ae.S., and Mr. R. Hafner, F.R.Ae.S., are to join its board. Mr. Boddington will become technical director (development), and Mr. Hafner will become technical director (research).

THE GENERAL ELECTRIC COMPANY, Ltd., states that Mr. G. A. Marriott, managing director of its subsidiary the M-O Valve Company, Ltd., has intimated his intention to retire in March next year. He will be succeeded as managing director of the company by Mr. J. Bell, deputy director and manager of G.E.C. research laboratories and a member of the M-O Valve board.

TUBE INVESTMENTS, Ltd., announces that Mr. Robert Atkinson, M.I.Mech.E., M.I.Mar.E., has been appointed managing director of the group's engineering division with effect from March 1, 1961.

FORD MOTOR COMPANY, Ltd., announces that Mr. J. Peter Higgins has been appointed as manager, sales planning and training office, tractor division. Mr. C. E. Sawyer has been appointed as manager, advertising department, tractor division.

THE INDEPENDENT TELEVISION AUTHORITY announces the promotion of three of its engineers to be engineers-in-charge at three of its new transmitters. Mr. H. N. Salisbury to be engineer-in-charge of the Caldbeck station near Carlisle; Mr. K. Archer to be engineer-in-charge of the Caradon Hill transmitter in Cornwall; Mr. G. W. Stephenson to be engineer-in-charge at the Stockland Hill station in Devon.

WORTHINGTON-SIMPSON, Ltd., announces that, following the retirement of Sir Samuel R. Beale, K.B.E., M.I.Mech.E., Mr. P. B. H. Brown, M.I.Mech.E., M.Inst.R., has been appointed chairman of the company. Mr. Brown is also chairman and managing director of L. Sterne and Co., a director of the Glasgow Chamber of Commerce, a member of the Management Board of the Engineering Employers' Federation, and a member of the Scottish Committee of the Council of Industrial Design. He was appointed a director of Worthington-Simpson, Ltd., in 1949.

Business Announcements

HOLDEN AND BROOKE, Ltd., has moved its Bristol office to 10, Aberdeen Road, Bristol, 8 (telephone, Bristol 30927).

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., states that its aeronautical division is now being regrouped in new premises at Basildon, Essex.

RINGWAY MACHINE TOOLS, Ltd., 42, Barton Arcade, Deansgate, Manchester, 3, has been formed to handle exclusively in the United Kingdom all products made by "Heid" of Vienna.

MR. G. H. CHURCH, A.M.I.Mech.E., A.M.I.E.E., has retired from the Express Lift Company, Ltd., a subisidary of The General Electric Company, Ltd., after fifty-six years' service with the company.

DAVID ROWAN AND CO., Ltd., Glasgow, announces that it has signed a fifteen-year agreement with Wm. Doxford and Sons (Engineers), Ltd., to manufacture the Doxford "P" range of opposed-piston oil engines.

THE DISTILLERS COMPANY, Ltd., Chemical Group, Distillers House, 20-21, St. James's Square, London, S.W.1, is to set up an overseas division which will be responsible for Distillers' overseas chemical interests. Dr. H. K. Whalley, formerly division director in charge of development, will head the overseas division, and will be assisted by Mr. P. L. Bramwyche.

LLOYD'S REGISTER OF SHIPPING states that it has regretfully accepted the resignation of Sir W. Guy Ropner as a deputy-chairman of the Society and chairman of the sub-committees of classification, with effect from December 31. Mr. R. M. Turnbull has been elected to succeed him. Sir Guy remains a member of the general committee and chairman of the yacht sub-committee.

WILLIAM FOSTER AND CO., Ltd., together with its subsidiary, GWYNNES PUMPS, Ltd., has now become a wholly owned subsidiary of W. H. Allen, Sons and Co., Ltd., Bedford, and as a result there has been a re-organisation of the board of directors. Mr. C. V. Armitage has resigned his position as chairman of William Foster and Co., Ltd., and Gwynnes Pumps, Ltd., after serving on the board for a period of thirty-three years and as chairman and managing director during the last fourteen years. Mr. W. Kenneth G. Allen has been elected a director and chairman of both William Foster and Co., Ltd., and Gwynnes Pumps, Ltd., and Mr. H. Norman G. Allen has also been appointed a director of William Foster and Co., Ltd.

S. WERNICK AND SONS, Ltd., has opened London offices at 64-66, Oxford Street, London, W.1 (telephone, Langham 4847/9). The company has also announced the following changes in administrative duties of the board of directors: Mr. S. Wernick, Jnr., who has been in charge of production at the Brownhills, Staffs factory, becomes chairman of the board, and is responsible for production at Brownhills and the factory at Wolverhampton, as well as Dainty, Smith and Co., Ltd., a subsidiary also located at Wolverhampton. The former production director at Wolverhampton, Mr. M. Nieman, has taken over at the Billericay factory in a similar capacity. In addition to their duties as sales directors Messrs. N. and J. Wernick have been appointed joint-managing directors. Mr. L. Wernick, hitherto production director at Billericay, heads a new department which is being set up to centralise the firm's buying activities, and he will also be responsible for the development of the factored goods division. Mr. C. E. Symonds, a director of Dainty, Smith and Co., Ltd., and Linden Finance (Midlands), Ltd., has been appointed to the main board.

Contracts

BOVING AND CO. (ANZ) PTY., Ltd., the Australian subsidiary of Boving and Co., Ltd., of 41-7, Strand, London, W.C.2, announces that it has secured a contract to supply three 42,000 h.p. vertical Francis turbines to the New Zealand Electricity Department for installation in the Aratiatia Power Station in New Zealand.

GOOLE SHIPBUILDING AND REPAIRING COMPANY, Ltd., has received an order for two trawlers from H. L. Taylor, Ltd., each ship having a length overall of 127ft by 25ft beam by 12ft 3in deep, and being powered by a Mirrlees six-cylinder diesel engine of 700 s.h.p. Another order is for a diesel-engined dry cargo vessel of 2350 tons deadweight, and measuring 260ft length overall by 39ft beam by 18ft moulded depth.

THE MITCHELL CONSTRUCTION COMPANY, Ltd., of Peterborough, has been awarded a third contract by the North of Scotland Hydro-Electric Board in connection with the Loch Awe scheme. The contract involves the construction of a concrete gravity dam across the outlet of Loch Nant, 1150ft long by 80ft high, together with overflow spillway and channel, the construction of access roads and other ancillary works. The total value of the three contracts is over £770,000. The civil engineering consultants for the Nant section of the Awe scheme are Messrs. Babtie, Shaw and Morton of Glasgow.

THE LOEWY ENGINEERING COMPANY, Ltd., has received through Mannesmann Export G.m.b.H. an order for a mains frequency induction heating installation for steel billets. The equipment will be installed at Mannesmann A.G., Roehrenwerk, Remscheid, Germany. It is worth over £250,000. Nominal capacity is 21 tons per hour, with provision to increase the output at a later stage to 28 tons per hour. The installation will have a power rating in excess of 10MW, and is claimed to be the largest induction heating installation in the world for a steel extrusion plant. The billet heating equipment is for a Loewy 3100-ton hydraulic extrusion press plant for steel, of new design, which is at present being built.

BRISTOL SIDDELEY ENGINES, Ltd., is, the Central Electricity Generating Board announces, to receive an order valued at about £200,000 for a 15MW peak-chopping and stand-by turbo-alternator using as a gas generator an "Olympus" turbo-jet. The "Olympus" is a compound engine, but to avoid expensive redesign of a fully developed low pressure turbine there will be added a third turbine with a lower rotational speed. While the gas generator weighs 2 tons, the power turbine will weigh 9 tons; the weight of the 3000 r.p.m. alternator will be approximately 60 tons. The set will be installed at the Hams Hall power station near Birmingham, and is intended to go into operation in 1962. The economic advantages of a highly rated engine for this application were outlined on page 826, December 18, 1959.

Award

THE COUNCIL OF THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY has awarded the Duddell Medal to Dr. J. B. Adams, director-general of CERN (the European Organisation for Nuclear Research), for his leadership of that team.

Death

As we go to press we have learned with regret of the death of Sir John Edward Thornycroft, K.B.E., the governing director and chairman of John I. Thornycroft and Co., Ltd. Sir John, who died at his home in the Isle of Wight on Monday, November 21, was in his eighty-ninth year, and was an honorary vice-president of the Royal Institution of Naval Architects, and was president of the Institution of Mechanical Engineers in 1937, and president of the Institution of Civil Engineers in 1942-43.

CONTINENTAL AFFAIRS

by Our Continental Editor

Fuel Oil Injection in Blast-Furnaces

Full-scale trials of a blast-furnace have been carried out by Société des Acieries de Pompey to investigate the effects of injecting fuel oil. The furnace was operating on run-of-mine ores and with a blast temperature approximately 100 deg. Cent. higher than normal. Under those conditions, injection of 45 kg to 50 kg of oil per tonne of pig iron produced, with corresponding reduction in the coke consumption, was found to increase the output by about 9 per cent ; this was accompanied by a small saving in production cost which, however, disappeared when output was further increased to 13 per cent above normal. An increase of up to 18 per cent has been found to be possible without excessively raising the coke consumption or the amount of dust produced.

AN important factor hampering the continued expansion of the European iron and steel industry has been the comparative shortage of grades of coal suitable for turning into blast-furnace coke. The situation seemed particularly threatening a few years ago, and in consequence, researches were undertaken which aimed at improving the economy and productivity of the blast-furnace. These investigations have received the active support of the High Authority of the European Coal and Steel Community.

A major project in this connection has been the international low-shaft furnace at Liège. The aim there has been to develop a furnace able to use softer grades of coke of which the supply was more plentiful. At the same time, research was carried out into the question of oil-firing, and suitable injection equipment was designed. Results having shown this line of approach to be a promising one, it was decided in 1956 to pursue the matter further. Accordingly, an agreement was concluded with the Société des Acieries de Pompey which already had carried out some oil-firing experiments in 1950–52, to conduct further trials with the financial support of the High Authority.*

The blast-furnace selected for the trials, No. 3 Furnace at the company's steel plant at Pompey, Meurthe-et-Moselle, has a hearth of 4·8m diameter, a maximum diameter of 6·84m, and a height from the iron notch to the underside of the bell of 25·85m. The total useful volume is 542·8 cubic metres, of which the hearth accounts for 50·6 cubic metres. Our illustration (Fig. 3) shows part of the furnace, including the hearth and tuyeres, in sectional elevation. There are eight normal tuyeres, six of 180mm diameter and two of 150mm diameter, as well as eight positions for bosh tuyeres of 130mm diameter at a 1·635m higher level. Of the latter, however, only four were fitted.

There are three Cowper stoves, each comprising 1590 tonnes of bricks ; two stoves being in use at any one time. Nominal blast temperature was 780 deg. Cent., the quantity amounting to 38,000 to 45,000 cubic metres per hour at a pressure of 0·53 kg to 0·60 kg per square centimetre.

The possibility of substantially increasing the blast temperature was of fundamental importance. Unless this can be done, an addition of oil fuel has no technical interest as it tends to chill the melt and the slag without, on balance, showing any worthwhile saving in fuel cost. The tests fell into two main sections. During 1959, seven series of preliminary trials were carried out, each lasting about ten days. These were followed by a control run in December and the main test runs in the period January–April of this year. Self-fluxing run-of-mine ores were used throughout, and it is stressed that the results may be considered to be valid only for those conditions. A study of the effects of using a blast enriched with oxygen is to be carried out at a later date, as is research involving the injection at 1400 deg. Cent. of reducing gases obtained by the cracking of oil fuel.

*"Recherches sur l'injection d'hydrocarbures dans les hauts fourneaux : Essais d'injection de fuel liquide léger dans le haut fourneau No. 3 de Pompey marchant en minerai tout venant," Haut Autorité de la Communaute Européenne du Charbon et de l'Acier. *Luxembourg/Bruxelles* : Services des Publications des Communautés Européennes.

Injection Equipment

Light fuel oil (4·79 deg. Fah. at 20 deg. Cent.) was delivered from a tank wagon to a 2·5 cubic metre buffer reservoir and hence to the pumping station. After filtration, the oil was boosted to a pressure of 18 atmospheres gauge by two pumps operating in parallel and capable of delivering into the common line a quantity of 2 tonnes per hour.

At the furnace the flow was controlled by an electrically-operated valve, and thereafter divided into four branches, each of which was provided with a venturi meter. For cleaning purposes, compound air at 5 to 7 atmospheres could be admitted to the branch pipes, the venturis being protected by non-return valves.

Each branch pipe then divided again, so that a total of eight oil-lines was formed, each with its own control valve and pressure gauge. Each pair served adjacent injection nozzles at the blast-furnace, the connections being made with flexible hose.

Compressed air for atomisation at 5 to 7 atmospheres was supplied from a ring main. Connections to the injectors were made with hose as in the case of the oil-lines, and were also controlled individually by valves.

Two designs of injector gave satisfactory service. One was incorporated in a water-cooled jacket like a tuyere (Fig. 1). This had an overall length of 1·45m, and penetrated into the interior of the furnace a distance of 0·8m. Each injector was capable of delivering up to 200 kg oil per hour, beyond which the furnace became saturated and fuel began to escape. (This rate of 200 kg per hour was equivalent to an addition of 70 kg of fuel oil per tonne of iron produced.)

The second injector, shown in Fig. 2, was similar to the design used in connection with the Ougrée low-shaft furnace. Cooling as well as atomisation in this case was accomplished by compressed air.

While the first kind of injector was used at the level of the bosh tuyeres, the other design was incorporated in a normal tuyere as shown in the illustration.

Preliminary Tests

Seven preliminary test runs, each lasting about ten days, were carried out at various dates between January and September of last year. In each case the dependent variable was the amount of oil which had to be added to maintain the blast 100 deg. Cent. above the normal value. The factors which were independently varied were site and manner of injection (either at bosh level without air atomisation, or at normal level with atomisation) and the state of the bosh tuyeres (open or closed). Oil consumption fluctuated in a somewhat inconsistent manner, varying between 32 kg and 70 kg per tonne of iron produced. Such variability probably was due to changes in the quality of the ore, as the runs were too short to even out this effect. However, an increase in output was observed which was of the order of 10 per cent.

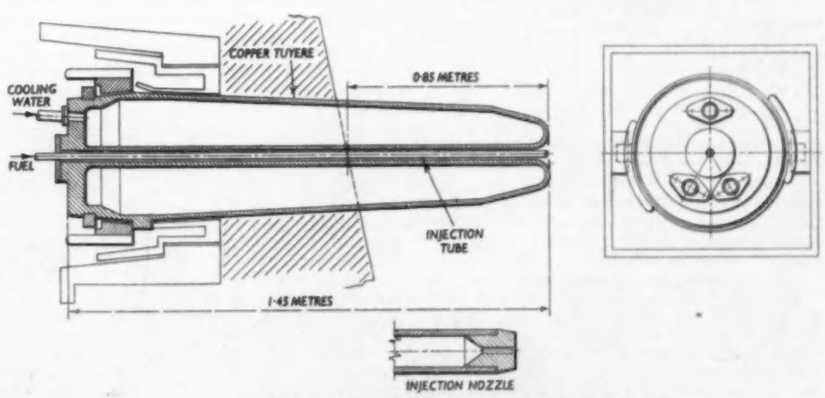


Fig. 1—Tuyere for fuel injection (first design)

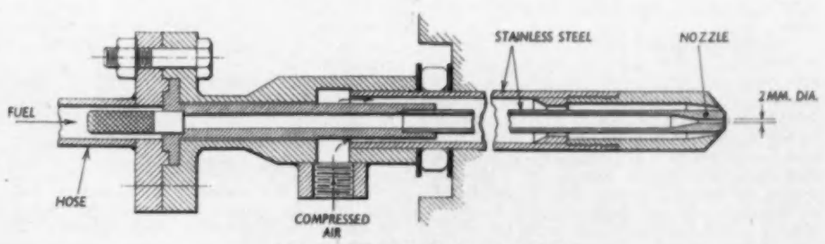


Fig. 2—Fuel injector (second design)

CONTINENTAL AFFAIRS *(Continued)*

TABLE I—*Blast-Furnace Operation with Injection of Fuel Oil*

Test Period	Control (December 5–25, 1959)	IA (January 12–31)	IB (February 1–12)	IIA (February 16–29)	IIB March 1–11	IIIA (March 15–21)	IIIB (March 22 -April 22)
Saizerais Ore, kg. per tonne iron	500–700	669	800	566	425	524	525
Coke (screened, dry) kg. per tonne iron	1007·9	905·9	944·4	922·6	889·4	908·9	884·7
Coke (corrected)*, kg per tonne iron	—	878·1	—	905·9	908	933	927
Fuel oil, kg per tonne iron	Nil	53	47	46	40	44·2	49·1
Heavy dust, kg per tonne iron	200	183·7	—	220·6	250·6	252·1	256·9
Output, tonnes per day	258·2	281·5	256·9	282·1	304·2	304·9	288·2
Output, tonnes per hour of operation	10·76	11·73	10·71	11·75	12·67	12·70	12·01
Yield, gross net per cent	29·53 / 32·43	29·35 / 31·93	28·09 / 30·81	28·92 / 31·98	29·44 / 33·10	29·47 / 33·16	29·91 / 33·81
Melt : Si per cent	0·60	0·60	0·58	0·68	0·65	0·56	0·65
Slag : $i=\frac{CaO}{SiO_2}$	1·44	1·44	1·50	1·52	1·52	1·45	1·47
Blast Temperature, deg. Cent.	781	868	870	902	904	897	913
Gain in Output, per cent	—	+9	−0·5	+9·23	+17·79	+18·07	+11·62

* For yield = 32·43 per cent, blast temperature = 900 deg. Cent., Si in melt = 0·60 per cent.

MAIN TESTS

In the period December 5 to 25, 1959, the blast-furnace was operated in the normal manner without fuel oil and measurements were taken to serve as a datum of comparison with the subsequent main test runs (Table I). Three main tests were carried out : From January 12 to 16 and January 20 to February 12 (IA and IB = twenty-nine days), fuel was injected through the normal tuyeres, the bosh tuyeres remaining closed. From February 16 to March 11 (IIA and IIB = twenty-five days), fuel was injected as before, but two of the bosh tuyeres were open. Finally, from March 15 until April 22 (IIIA and IIIB = thirty-nine days) fuel was injected through four of the bosh tuyeres only.

The charge included ore from Droitaumont, having an iron content of about 35·8 per cent, 13 per cent CaO, and 7·2 per cent SiO_2 ; ore from Saizeras with an iron content of 30·8 per cent, 13 per cent CaO, and 13 to 14 per cent SiO_2 ; some Kiruna ore, as well as scrap and other metallic additions. Fines 0–20mm were screened out of the coke.

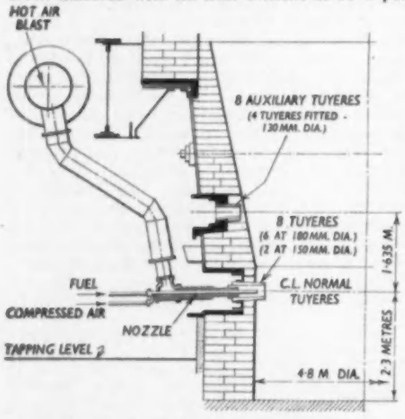


Fig. 3—Part sectional elevation of No. 3 blast-furnace. Hearth diameter = 4·8m., total useful volume = 542·8 cubic metres

Table I shows the principal quantities. The " corrected " amounts of coke are for comparison purposes and based on a net yield of 32·43 per cent as during the control period, a silicon content in the melt of 0·6 per cent, and a blast temperature of 900 deg. Cent. During the control period, for each ton of iron produced the charge consisted of 2700 kg of Droitaumont ore, 500 kg to 700 kg saizerais, 100 kg Kiruna D and C_2, and 120 kg of metallic additions.

Throughout the test period, the lime content of both the Droitaumont and the Saizerais ores kept increasing which would have resulted in an increase in the proportion of Saizerais ore from 500 kg to 1000 kg per tonne of iron, resulting in major changes in granulometric composition and concentration. The resultant drop in production is dramatically seen in the table when during the period February 1 to 12 the amount of Saizerais ore had been allowed to rise to 800 kg, causing output to fall below the level of the control period. In order to reduce the proportion of Saizerais, a small quantity of gravel was added in the second and third test periods.

Injection of fuel at the rate of 45 kg per tonne of iron through the normal tuyeres, as in the first two tests, was accompanied by a rise in the blast temperature of 85 deg. to 125 deg. Cent. Measurements of the temperature of the melt showed a rise of 20 deg. to 30 deg. Cent., with the same silicon content of the melt and basicity index of the slag. Correspondingly, the sulphur content of the melt was less, so that for a fixed silicon content of the melt, injection of fuel oil permits the lowering of the basicity index from 1·50 to 1·30 without raising the sulphur content. The latter averaged 0·04 per cent for 0·63 per cent of silicon and a slag basicity index of 1·46. The sulphur content of the slag gradually decreased from 1·36 per cent in the control period to 1·18 per cent in the third test period.

Trouble in operation was experienced from injectors getting blocked with carbon deposits through overheating. Owing to the fact that injectors were connected in pairs to the same supply, any restriction in one simply tended to increase the flow in the other at its own expense, thereby reducing the cooling effect and favouring the formation of further deposit. Although the true answer seems to be to supply each injector from its own group, no difficulties are reported since last May when it was decided to operate with only four injectors at normal tuyere level and with two bosh tuyeres open. It has been found easy with this mode of working to step up output by 10 per cent, using a blast temperature of 900 deg. Cent., and injecting 45 kg of fuel oil per tonne of pig iron.

CERN Computer

An " I.B.M. 709 " electronic computer, consisting of twenty-five separate units and weighing nineteen tons altogether, was recently delivered by air to Geneva, and is now being installed on the site of the European Organisation for Nuclear Research (CERN). This computer will be the biggest of its kind in operation on the continent of Europe. Capable of performing 42,000 operations per second, it is equipped with a magnetic information store capable of holding 327,680 digits, each of which can be reached in twelve micro-seconds. These facilities enable it simultaneously to perform computations and to store and produce information at the rate of 25,000 digits per second.

Since 1958, CERN has had an electronic computer similar to those used in several European laboratories. This tool proved inadequate, however, to meet growing computing requirements resulting from experiments made with CERN's two big particle accelerators, from which comes a continuous flow of numerical and photographic information that must be evaluated.

Electronic computation with the most up-to-date equipment will enable CERN to perform in this field one of its essential functions, namely that of fostering new scientific methods.

Dinslaken Refinery

The new B.P. refinery at Dinslaken, Ruhr, was officially opened on October 20. Stage I of the refinery is now commissioned. This comprises two crude oil distillation units (each of 50,000 barrels a day capacity) which will enable the refinery to deal with a throughput of 4,400,000 tons of crude oil annually. Other items of equipment include a catalytic reformer, hydrofiner, and copper chloride treatment units, and a sulphur recovery plant.

Construction of a second stage is in hand, which when completed will add a catalytic cracking plant with associated vacuum unit, and a bitumen plant.

The refinery is owned and operated by the Group's German associate, BP Benzin und Petroleum A.G., Hamburg. Building work officially started on November 18, 1958, and more than 350 firms, mostly German, have been concerned. The construction force at its peak numbered 1700.

The wide range of products from the new refinery will include the highest grade motor gasolines, aviation turbine fuels, diesel oil, gas oil, fuel oils, liquid petroleum gases, and petroleum chemical feedstocks, and—when Stage II is completed—bitumen. Crude oil for the refinery is drawn from the Wilhelmshaven–Cologne pipeline which is owned by a company in which BP has an interest. About half of the products are to be distributed by Rhine barges. These barges are loaded at a recently constructed harbour, sited at the junction of the Rhine and the Lippe-Seiten Canal, which is linked with the refinery by a 3-mile pipe. Products are also despatched from the refinery by road and rail.

Among the interesting features incorporated in the BP Ruhr refinery is the " in-line " system for blending finished products. With this system the major quantity of products is stored in component form and the blender is run to make particular finished products as and when required.

Safety on the Roads

A three-day course of studies connected with the subject of road safety is being arranged by the Arbeits und Forschungsgemeinschaft für Stadtverkehr und Verkehrssicherheit (Working and Study Group for City Traffic and Road Safety), Cologne-Lindenthal, Universitätsstrasse, 22. Like a similar course held last year it is being organised in co-operation with the Vehicle Technology Sections of the VDI, Düsseldorf, the Ministry for Economics and Transport of North Rhine-Westphalia, Düsseldorf, and the Federal Association of Communal Road Organisations, Cologne-Marienburg. The course is intended to acquaint top administrative personnel and authorities, as well as others, with the latest results of scientific research into technical and sociological, as well as psychological and physiological aspects of this field. It will be held in Cologne from November 28 to 30, and repeated from December 5 to 7 at Essen, and December 12 to 14 at Hamm.

Measurement of Pedal Force

Under German regulations the amount of force which needs to be applied to the brake pedal of a road vehicle must not exceed a specified maximum value. In order to enable this force to be measured, the firm Robert Bosch G.m.b.H., Stuttgart, has produced the model " EFSV57 " instrument which can equally well be employed in the workshop, on roller or plate test rigs, and during road tests in conjunction with a decelerometer.

The instrument works electrically. The transducer is clamped to the brake pedal or foot-operated valve, while the indicator to which the transducer is connected by a cable is hung from a hook in a convenient position.

Depending on the setting of a lever at the transducer, one can determine either the maximum value of the pedal effort or the instantaneous value. In the first case, the instrument has to be set back by hand. The useful measuring range is 0–90 kg with a full scale range of 100 kg. The instrument is operated by means of a torch battery, and if desired can readily be re-calibrated before each series of readings.

THE AMERICAN SCENE

by Our American Editor

Machine Tool Exposition and Production Engineering Show at Chicago

No. IV (*Continued from page 860, November 18*)

The 1960 Machine Tool Exposition and the Production Engineering Show were held, respectively, at the International Amphitheatre and the Navy Pier in Chicago from September 6 to 16 and were attended by over 150,000 visitors. Compared to the previous exhibitions held in 1955, there has been a major increase in the application of numerical control to both standard and special-purpose machine tools. This article reviews the more important advances in the design, construction and performance of the machinery shown and deals particularly with the present state of automatic machine tool control in the United States.

Micromatic Hone Corporation

The Micromatic Hone Corporation, of Detroit, Michigan, exhibited an automatic transfer installation comprising several individual honing machines, as shown in Fig. 26. From left to right, the first machine is a "Model 836-2 Microflat" unit, offering a completely automatic set-up to microhone simultaneously both flat surfaces of workparts. In one operation, this machine generates to close tolerances the part thickness, parallelism, surface flatness and required finish. The work carrier assembly accepts the parts from the loader and feeds them between the abrasive discs. The abrasive wear compensation assembly makes adjustments for the wear of the discs and controls the thickness of the workpieces through a feedback signal from the air gauge which is constantly measuring the parts for size. As the workpieces emerge from between the abrasive discs, they pass through a built-in air gauge that measures them for thickness and indicates their size on a dial. The speed of the unload conveyor is synchronised with that of the work carrier through a common drive.

The next machine is a "Model 2-2V3 Microhoner." Designed for adaptation to any degree of automatic operation, this mechanical-stroke machine is capable of microhoning a wide variety of parts to close tolerances at high production, while generating final functional accuracy and surface finish. The workpieces may be automatically processed through the complete cycle: loaded, indexed, shuttled, pre-gauged, microhoned, post-process gauged, segregated and ejected. On this particular machine, in-process gauging is accomplished through the "Jet-Matic" tool: work-pieces are automatically sized along the full length of the bore. The actual i.d. size is indicated on dials during the honing cycle, and also when the finished bore is being post-process gauged. In segregation, every workpiece is culled according to one of three finished size categories: (1) within the required tolerance; (2) on the high side; and (3) on the low side. All unload chutes discharge the workpieces to the front of the machine. In addition to the spindle stroke of 3in, this model has a 13in head travel. This feature provides ample room for the withdrawal of the tool and visual inspection of the workpiece.

The third machine is a "Model 738-C Microhoner." This mechanical-stroke, completely automatic machine has the speeds and controls required to hone short bores and small diameters to close tolerances at high production. It generates final functional accuracy—bore diameter, geometry and surface finish—while maintaining the relationship of the bore to other surfaces of the part. Its fully automatic operation provides loading, indexing, shuttling, prechecking, honing, post-process gauging, segregating and ejecting. High and low spindle head mounting provisions permit adaptation of the machine to long or short bores, or to parts of unusual shapes. The table has a 5in drop-away, making it possible, in certain applications, to hone a part that is longer than the stroke of the machine.

Fig. 26—Automatic transfer installation of four "Micromatic" honing machines at the exhibition

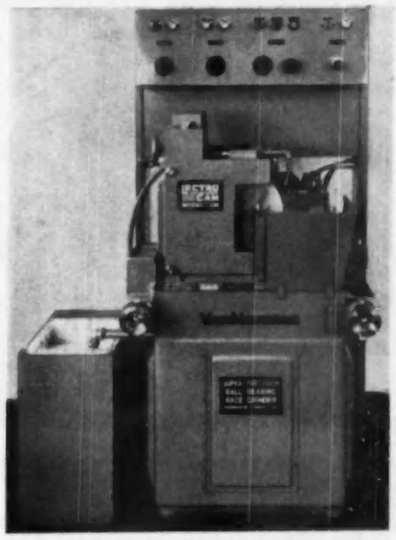


Fig. 27—Van Norman "Lecto-Cam" miniature ball bearing race grinding machine

The final machine is a "Model 2 HRI-5 Microhoner" developed for the automatic processing and handling of anti-friction bearing raceway rings on a multiple-spindle set-up. The microhoning of ball tracks generates a superior functional surface that ensures a quieter running bearing. The positive splined drive transmits non-slip power to the tool. This drive assembly offers visual oscillation indication and simple angular adjustment. Pitch radius adjustment is controlled by "quick-change" set-up blocks to minimise changeover downtime. The automatic loader assembly is designed to accommodate a range of sizes. The stone adaptor and body are independent, replaceable items; therefore the same tool will accommodate several different size stones. The machine automatically shuts down when stone replacement is necessary.

Van Norman Machine Company

An exhibit of unusual interest was the demonstration of its new "1-M Lectro-Cam" miniature race grinder (Fig. 27) by the Van Norman Machine Company, Springfield, Massachusetts. The machine was in operation at Chicago, grinding a 0·039 in ball groove into 0·062 in o.d. inner races of miniature ball bearings. In this grinding operation, size is held to within 50-millionths of an inch. Such precision exceeds the Class 7 ABEC (American Bearing Engineers Code) accuracy of the entire bearing assembly. The new plunge-cut grinder achieves its accuracy with a development called the "Lectro-Cam." Under an automatic cycle, a master cam precisely controls rapid traverse, fine feed and grinding-wheel retraction. To machine a miniature race, the operator positions it $^{1}/_{32}$in above the centre line of the grinding wheel, as in a typical centreless grinding operation. The workpiece, positioned between the grinding wheel and a high-speed steel control wheel, lies atop a carbide-

THE AMERICAN SCENE *(Continued)*

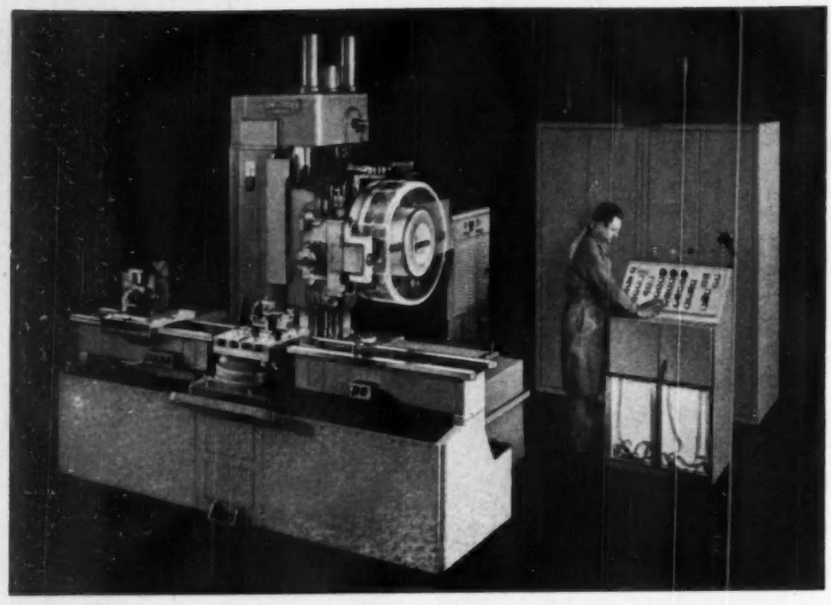


Fig. 28—Kearney and Trecker " Milwaukee-Matic " tape-controlled production milling machine with automatic tool changer

tipped work-rest blade. A hold-down finger, in vertical alignment with the work-rest blade, presses the work securely against the blade. The cutting of the part is done with a grinding wheel that has been dressed for the radius required, and thinned to obtain proper contact with the part. As grinding progresses, pressure is regulated by the " Lectro-Cam " in-feed, in which a master cam controls rapid traverse, fine feed, and grinding-wheel retraction automatically. The movement of the cam during the grinding operation energises electrical circuits that control the wheel movement. Incidentally, this master cam can be used on all the jobs that the machine can handle. A mechanical adjustment of the cam is the only change required. Besides the feed control, the machine has another feature of special interest : co-ordinated dressing and size compensation. As the grinding wheel dresser advances for a dressing cycle, an in-feed unit connected to the control wheel receives a signal, which causes the control wheel to advance the same amount to correct for size.

The grinder is equipped with an easy-to-read control panel which enables the supervisor to see that the machine is being operated at pre-set rates. All rates are set on knobs visible from the front of the machine, and there are indicating lights for the grinding cycle, grinding-wheel start, regulating wheel start, and dresser start. The filtration system of the machine consists of a simple, basket-type receptacle with a replaceable fabric liner. In this system, coolant is delivered under controlled pressure to a hooded enclosure, which confines the mist that forms.

Kearney and Trecker Corporation

One of the outstanding examples of automatic machine tool design at Chicago was the " Milwaukee - Matic " production milling machine (Fig. 28) exhibited by the Kearney and Trecker Corporation, of Milwaukee, Wisconsin. There were two of these so-called " Model II " machines on display ; one was equipped with a rotary table, and one with an eight-position index-table. Both machines are completely numerically controlled, employing a standard 1in wide, eight-channel punched tape. This equipment will mill, drill, bore, ream, tap, select and change its own tools ; change feeds and speeds ; and transfer the workpiece, all by tape command. The concept employed provides for a wide variety of simple or complex machining operations on a given workpiece with a single set-up in most instances. All machine motions are powered by a 30 h.p. hydraulic unit. Accurate positioning, satisfying the most demanding tolerances, is accomplished through an electro-hydraulic system controlled by electrical feedback. The spindle speed ranges are from 0 to 4000 r.p.m. in increments of 10 r.p.m. The feed range is from 2in to 99in per minute in increments of 2in per minute, with a rapid-traverse rate of 200in per minute. All three axes of the machine are driven by high-performance hydraulic servo motors through single-contact spiroid reduction gears fixed to recirculating ball lead screws. The axes of motion, X-longitudinal, Y-vertical, and Z-depth, respectively, have ranges up to 24in, 20in and 16in per minute.

The index table of the machine accommodates a removable work pallet. The X-Y-Z co-ordinate relationships are established when the work pallet is clamped in position on the index table. The co-ordinate relationship of a workpiece with respect to the work pallet can then be established. Therefore, the workpiece is held in a known position so that each surface to be machined has an absolute location with respect to the machine spindle.

The " Milwaukee-Matic " is equipped with an automatic tool changer. The machine has a capacity of thirty-one tools ; thirty in the tool storage magazine and one in the spindle. Tape commands will select any tool in the storage magazine and transfer it to the spindle. The tool holders accomplish two purposes in addition to holding the tool : (1) Identification of the tool ; and (2) location of the tool with respect to the centreline and front face of the spindle.

Tools are identified by means of a four-digit code, which is divided into two sections. The first two digits identify a group number, and the second two digits identify a tool number in that group. There are thirty-one groups and thirty-one tools within each group giving a possible 961 codes. Due to an electrical interlock which actuates the tap float mechanism, groups 30 and 31 are reserved for taps.

The co-ordinate locations of the X-Y-Z axes are established by the position of the centreline and front face of the spindle. Since the geometry of a tool will affect these co-ordinates, the diameter and " setting distance " (end of tool to location face of holder) of a tool must be specified for each operation. Tools up to 2¼in diameter and/or a 7½in setting distance can be changed automatically. Tools larger than these must be changed manually.

Ex-Cell-O Corporation

A numerically controlled machine which can be converted from a template grinder to a boring and turning machine through interchangeable heads was displayed at the booth of the Ex-Cell-O Corporation, Detroit, Michigan. Called the " Model 922 Numera-Trol," this two- or three-

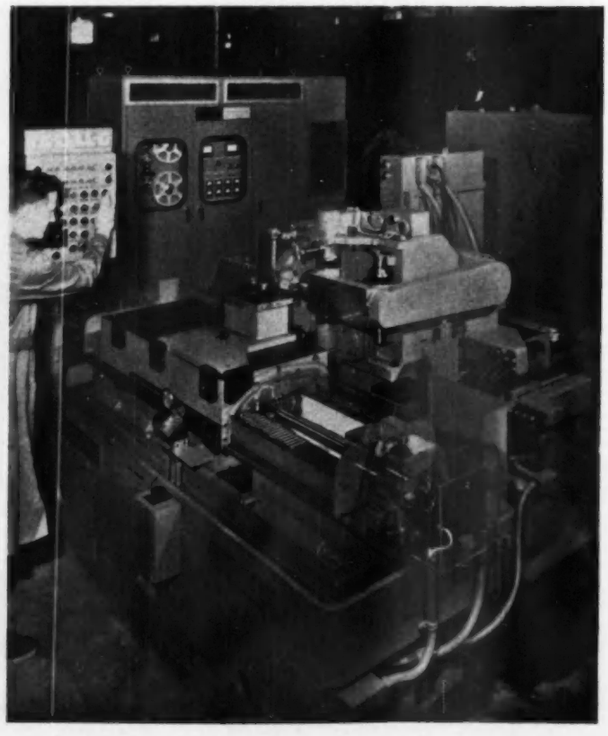


Fig. 29—Ex-Cell-O " Numera-Trol " contouring machine with tape control

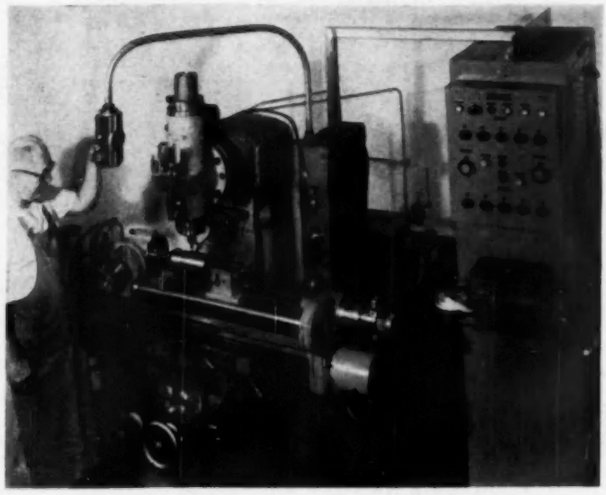


Fig. 30—Brown and Sharpe "Numericam" tape-controlled cam milling machine with General Electric universal positioning control

dimensional tape controlled machine (Fig. 29) has an extremely heavy, rigid bed, hand-scraped anti-friction screw and nut assemblies and preloaded ball thrust bearing supports on each end.

The "Numera-Trol" contouring machine is a versatile precision unit for performing inside and outside contouring of regular and free-form hemispheres, scribing and grinding flat templates and grinding circular cams. This flexibility of operation is achieved through interchangeable assemblies; one for boring and turning operations and another for scribing and grinding. In addition to these units mounted on the main slide, the cross slide accommodates a tool holder assembly for use in contouring, work fixtures for scribing and grinding flat templates and a rotary attachment for grinding circular cams.

Evidence of the accuracy of this machine is the fact that the main slide and cross slide are controlled in increments of 25 millionths of an inch, whether operated automatically through the tape control system or by manual control during set-up. The ways that support the slides are hand-scraped to surface plate accuracy and parallelism is checked by optical flats. Precision bearings, individually matched and operating in oil, are incorporated in both the flat and V-ways. Similar precision is built into the slides themselves, and the low "stiction" value achieved reflects the care exercised during every step in assembly. The cross slide weighs just under 1000 lb; yet a thrust of only 5½ lb overcomes static inertia and only 5 lb is necessary to maintain steady movement. The precision turning and boring spindle is driven by a variable delivery hydraulic motor. When such parts as hemispheres are turned or bored, the cutting speed is maintained constant by varying the spindle speed hydraulically to suit conditions. The grinding assembly is capable of grinding extremely accurate template contours on flat stock. Circular cams also can be ground, using a rotary attachment mounted vertically on the cross slide.

A heavy-duty precision spindle is mounted horizontally at the front of the grinding assembly and driven from a 2 h.p. motor. The spindle oscillates in a vertical plane, riding on preloaded ball bearings moving on two parallel guide bars. Oscillation results in a ground surface that is flat rather than curved to the shape of the grinding wheel. The oscillating movement is power-operated and the length of stroke adjustable.

Wheel dressing is either initiated manually or as a periodic function controlled by the tape. In the dressing operation, the normally oscillating grinding wheel spindle is brought to the centre of its stroke and hydraulically clamped. The dresser slide then feeds forward by the amount to be dressed. After the dressing operation, the main slide is automatically advanced to compensate for the reduced wheel size. The grinding cycle is then resumed when called for on the tape.

For precision machining of a high order, temperature controlled conditions are essential. Heat from the electronic equipment contained within the tape reading cabinets is effectively ducted away from the work area and the hydraulic power unit is water-cooled. Under these conditions it is possible to hold work tolerances of 0·001in in routine production of templates, and 0·0002in in contour boring and turning operations. Two rows of electronic counting tubes are provided on the control panel. During machining each row indicates numerically the respective dimensions by which the slides are removed from the start position.

By the movement of the hand knobs at the lower left on the panel, it is possible to advance or retract either slide by increments of movement ranging from one-tenth of an inch to 25 millionths of an inch. It is thus possible by simply dialling 25 millionths, to cause the main slide or the cross slide to advance or retract by just this amount.

Brown and Sharpe

One of the most interesting displays at the stand of the Brown and Sharpe Manufacturing Company, Providence, Rhode Island, was the "Numericam" tape controlled cam milling machine (Fig. 30), which is a modified version of a No. 2 vertical milling machine equipped with a General Electric Mark II universal positioning control. This control can position the index centre to one hundred thousandth part of a circle (five decimal digits) by either dial or eight-channel tape. The table position may also be specified by five digits; to one ten-thousandth of an inch over a 10in range.

The machining is started as follows: The tape is threaded through the tape reader. Then, with the "drill cycle" selector at "off," the "cycle start" button is pressed which causes the machine to position over the first hole location. An "in position" light shows when the servo drives have "homed in." The work is then oriented in both axes to agree with the starting figures. The zero position may be located anywhere in the machine range. The automatic cycle is then initiated by turning the drill cycle selector to "drill." As soon as the cutter feeds down at the pre-adjusted rate the next set of data is read from the tape. The cutter feeds down to a positive stop and after a slight dwell retracts to an adjustable upper limit. As soon as the upper limit is reached the index head and the table are re-positioned automatically. When the new position is reached the cutter repeats the down feed for the next cycle. The cycle can be interrupted at any time by turning the "drill cycle" selector to "off." The cycle will end with the spindle up. An automatic stop signal may be used at the end of the tape.

Cam paths can be produced at rates depending on the size of the cam follower. For highest speed it is recommended that the path increment be kept uniform along the path. The automatic cycle can be as fast as about sixteen strokes per minute. At 0·030in per path increment the machining speed is about 0·5in per minute along the path. The speed for the drilling of hole patterns is not high due to the fact that the positioning is accomplished at about 6in per minute. However, the accuracy will allow great savings for work in the size range of this equipment. Tapes for hole patterns may easily be prepared on a standard eight-channel "Flexowriter" typewriter.

When cam paths are machined by contouring, great care must be exercised to prevent cutter deflection from destroying the accuracy. In turning through short bends the cutter forces become large unless the feed rate is greatly reduced compared to straight portions of the path. This means that to obtain high accuracy, very advanced computers and machine controls must be used to allow for these deflection effects. Brown and Sharpe is using an IBM 610 "Auto-Point" computer for the calculation of cam data. The data tapes produced are converted to machine tapes by a small tape-to-tape converter. It is estimated that the use of the new cam milling machine and the IBM 610 computer in combination reduces the combined time of cam path calculation and the machining of the paths to about 10 per cent of the time for the desk calculator and hand positioning previously employed.

Cincinnati Milling Machine Company

A bridge-type profile and contour milling machine with numerical control was demonstrated by the Special Machine Division of the Cincinnati Milling Machine Company, Cincinnati, Ohio. Such machines have been designed especially for the milling of medium to large-sized parts of complex shapes and die-sinking

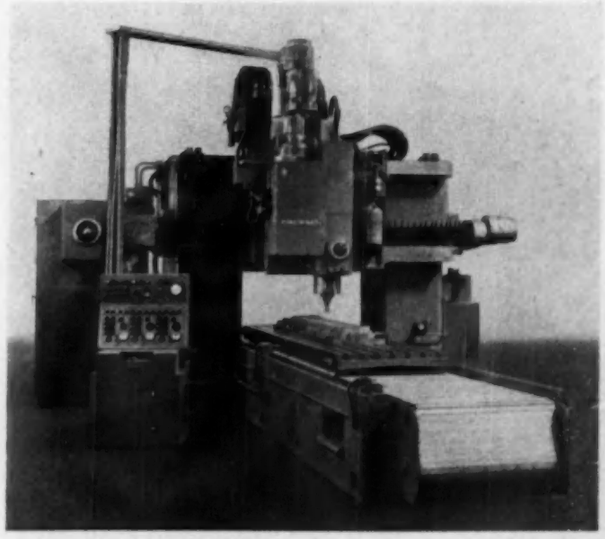


Fig. 31—Cincinnati bridge type profile and contour milling machine with "Acramatic" control

THE AMERICAN SCENE *(Continued)*

operations. They have ample horsepower and a wide range of spindle speeds for efficient milling of either ferrous or non-ferrous metals. All feed movements are hydraulically actuated and the machines are available with either automatic electro-hydraulic tracer control mechanisms or Cincinnati's "Acramatic" contouring control, a fully automatic numerical contouring control employing either punched tape or punched card input.

The 36in by 120in milling machine shown at Chicago (Fig. 31) has a 20 h.p. spindle drive, and twenty-four spindle speeds ranging from 30 to 3000 r.p.m. The machine has a bridge structure, with the vertical spindle mounted in a cross feeding carrier on the horizontal cross-rail. All feeds are actuated by hydraulic motors, the cross and vertical feeds being driven by precision ball bearing leadscrews and the table feed by rack and pinion, with an anti-backlash drive box. The table driving pinion is located close to the cutter, so that compressive effects are minimised and not changed by the length of table travel. The slideways for all axes are hardened and ground and equipped with anti-friction roller slides.

The machine may be controlled by the Cincinnati "Acramatic" contouring system, to provide complete control of accuracy, quality and production. The numerical input for the system is in the form of an eight-track, 1in-wide perforated tape as standard equipment. The tape input can be prepared on a standard "Flexowriter" and uses the standard decimal-binary code. Punched card input is also available if desired. The input data needed to prepare the tape consist of the co-ordinate information required to describe a nominal cutter centre path. In addition, other information affecting auxiliary functions, such as feed rates, spindle, coolant, &c., are coded on the tape to obtain complete automatic control of the machine tool.

Computer routines are available to simplify the preparation of contouring programmes through the use of general purpose digital computers for the preparation of numerical data input, although, when a computer is not available, computations can be performed with a desk calculator. With either direct preparation, or simplified routines using a computer, parabolic interpolation built into the control system greatly reduces the number of calculations and the amount of data which must be processed.

The control unit consists of the cabinet, the operator console, and machine-mounted components for servo drives and absolute position feedbacks. The rugged, sealed control cabinet houses the electronic and logic units arranged in bays on swing frames to provide maximum accessibility for servicing. The operator console houses the tape reader as well as manual and automatic cycle controls for the unit.

Parabolic interpolation requires the minimum number of input data points, and hence the minimum number of calculations. The smoother contours and controlled accelerations and decelerations provided by this method of interpolation are characteristic of this contouring control.

A feed rate override permits the operator to make on-the-spot adjustment of feed rate to tailor it to the actual cutting conditions without changing the taped programme. If need be, he can use this same control to stop the cutting cycle smoothly. Interruptions of the cutting cycle can be made at any time without marring the work surface. Furthermore, zero shift is provided by a group of calibrated ten-position switches arranged in decade fashion. 9·999in of shift is provided for each axis as standard equipment. The machine operator need only locate the work holding fixture approximately, according to his alignment instructions, and dial in the necessary corrections to bring the programme into exact alignment with the work holding fixture.

A simple, direct alignment system uses two directional error lights for each axis. The operator simply turns the control handwheel in the direction the light indicates. When both lights go out the axis is properly positioned. When all axes are properly aligned, the control of the machine tool is automatically transferred from the handwheel to the numerical control unit. The accuracy that can generally be expected from the machine tool to which the contouring control is attached, is within ±0·003in from the programmed tool path. However, close accuracies can be obtained when required by changes in the numerical control unit. These include providing an extra digit to accept numerical data specified to 0·0001in and adding compensation equipment consisting of a linear error cam and pick-off on the machine.

DeVlieg Machine Company

An interesting application of both dial positioning and numerical control to precision boring and milling machines was shown at the stand of the DeVlieg Machine Company, Royal Oak, Michigan (Fig. 32). This firm's "Spiramatic Jigmils" are used extensively for "jigless boring" a wide variety of production parts, such as pump housings, gear cases, aeronautical and instrument parts, and component parts for machine tools, printing presses, paper machinery and textile machinery. These boring and milling machines are usually equipped with the "Diatrol" system of automatic point-to-point positioning. The system provides a means of preselecting co-ordinate dimensions for the horizontal table movement and vertical movement of the spindle head. It allows direct dialling of positive or negative dimensions from any arbitrarily selected datum plane within the range of the control system. A push-button control automatically positions the table and spindle head at the preselected hole location in seconds. All settings are made on direct-reading dials; one dial for horizontal, and the other for vertical dimensioning. Positioning is automatic from the arbitrarily selected datum or zero point. The nature of this system makes it entirely practical for an operator to dial in co-ordinate dimensions directly from a blue print, with the resultant elimination of much of the mathematics normally associated with accurate jig boring work. While the "Jigmil" is performing the machining operation, the operator can preset for the next move. The system will measure and position well within the tolerance range of the machine. This system is ideal for tool room and experimental work as well as for "jigless boring" small-lot jobs.

In addition, the firm has now developed the so-called "Tapac" numerical tape control for its machines. Various degrees of sophistication are available in this tape system, depending upon the requirements of the customer. The basic "Tapac" system utilises the master measuring bar concept of the "Diatrol" system for the horizontal and vertical slide movements. Point-to-point measurement and positioning of the horizontal and vertical slides are controlled from a standard one-in-eight-channel binary coded punched paper or plastic tape. Machine functions such as selection of spindle speeds and spindle feeds, control of spindle depth of feed, automatic spindle rapid traverse, feed and retraction, as well as automatic advance to new hole locations, can also be programmed into the tape control. In addition to this, the system provides automatic locking of the slides, tool change warning signal, and operation number designation.

An important advantage of the system is the simple programming procedure for making a tape. Many of the automatic machine movements are functions of the electrical sequences of the machine itself and do not have to be programmed into the tape. Such functions as locking and unlocking of the slides, automatic table retraction, spindle rapid traverse, feed and return, automatic tape advance, and other functions are sequenced electrically with full safety interlocks—thus greatly minimising the programming effort and largely eliminating errors in programming. Only the basic information need be programmed into the tape, i.e. horizontal and vertical dimensional settings, spindle speeds and feeds, depth control setting and tool change. As a result of this greatly simplified programming procedure, not only is tape programming time substantially reduced, but possibilities of errors are also reduced. At the same time the simplified programming procedure for the system results in a very short training for the person who will do the programming.

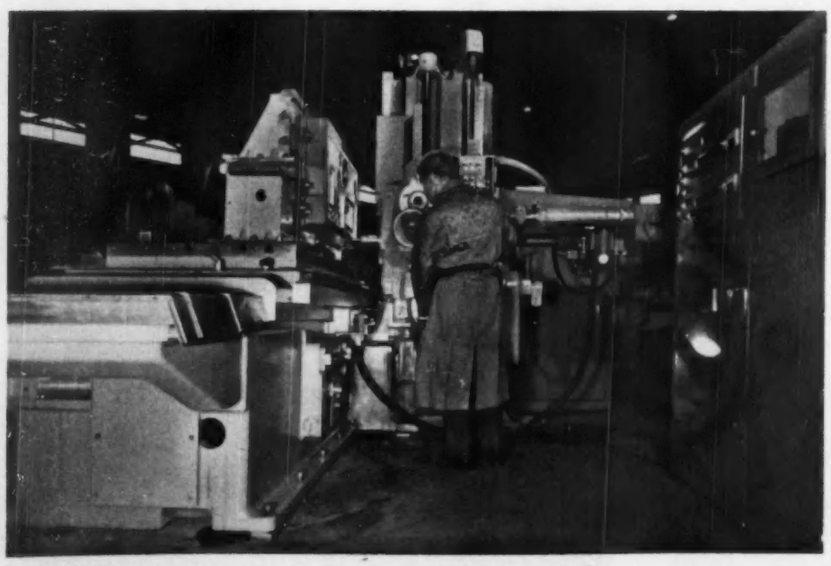


Fig. 32—DeVlieg "Spiramatic Jigmil" horizontal boring and milling machine with "Tapac" control system

Barnes Drill Company

The Barnes Drill Company, of Rockford, Illinois, exhibited its new "BarnesdriL Model 244" honing machine (Fig. 33), which is outstanding for the simplicity of its design and for the accuracy of its performance. Changeover from manual to automatic expansion can be accomplished without removing the spindle head. "Plugmatic" bore-to-bore sizing on the machine maintains size consistency within 0·0002in from bore to bore. The overall bore capacities range from ½in to 6in but large

diameter applications are dependent upon the amount of stock removal, the bore length and material.

A 5 h.p. motor provides power through a Vee-belt drive and a four-speed transmission. The upper limit of the stroke and stroke length are controlled by a dial mounted on the rear of the control panel arm. Hydraulic reciprocation is powered by a separate 3 h.p. motor. The speed of reciprocation is adjustable from 10ft to 75ft per minute through the use of the hydraulic control which is positioned with the hydraulic unit at the lower right side of the machine. Short stroking—a rapid reciprocation of the hone over a small length of the bore—can be performed at any point in the bore. Short stroking is used to bring high spots in the bore to size more quickly than with the normal operating stroke. The machine also can be equipped with a dwell mechanism. The purpose of this attachment is to create a hesitation or dwelling time at the bottom of the working stroke for bores that do not permit an overrun, such as blind end bores. While dwelling, the honing tool continues to rotate, but the reciprocation is stopped for a selected period of time.

Positive control of accurate final size is achieved with the "Plugmatic" bore-to-bore sizing mechanism. Without interfering with the function of the honing tool, the self-aligning gauging member attempts to size the bore on each downward honing stroke. Until the bore reaches pre-determined size, the spring-loaded gauge stops at the top of the bore. As size is reached, the plug gauge enters the bore, and the added travel permits the sizing control arm to trip the sizing limit switch, which actuates the co-ordinated machine controls to terminate the honing cycle at the end of that stroke. The

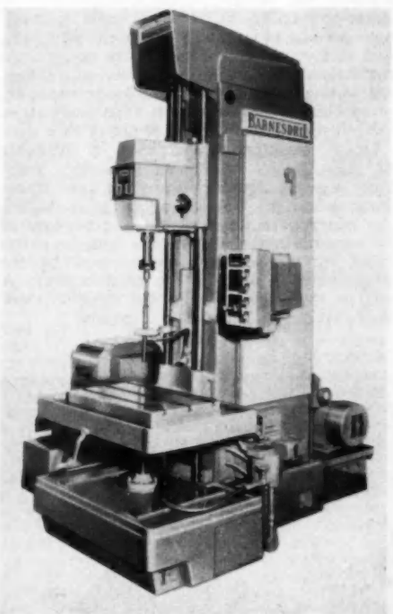


Fig. 33—"Barnesdril," Model 244, single-spindle honing machine with "Plugmatic" bore sizing unit

gauging member is carbide-tipped to provide long life. By gauging on the bore, the entire sizing operation is unaffected by eccentric or uneven stone wear.

The machine is equipped with a new electric hone expansion. After the hone enters the bore, a motor rapidly expands the honing stones to a predetermined point short of the bore wall, the traverse motor cuts out, and electric controls actuate the hone feed, which is infinitely adjustable. The bore sizing unit terminates the feed cycle when it de-energises the hone feed, and it activates the rapid collapse powered by the traverse motor. Compensation for stone wear is automatic. When the limit of stone wear is reached, lights on the control panel warn the operator, and interlocking controls prevent starting a new honing cycle until new stones have been inserted.

Sperry Gyroscope Company

A representative point-to-point positioning control system applied to a turret drilling machine was shown at the stand of the Sperry Gyroscope Company, of Lake Success, New York.

The system, as a whole, represents a combination of analogue and digital techniques so applied as to obtain maximum benefit from these two basic design philosophies. The measuring devices used are highly accurate linear transducers which provide measurements completely independent of, and unaffected by conventional transport mechanisms. The Sperry tape reader obviates the necessity for a shift register or memory store, thus greatly reducing the component bulk of the control and conversely increasing its inherent reliability.

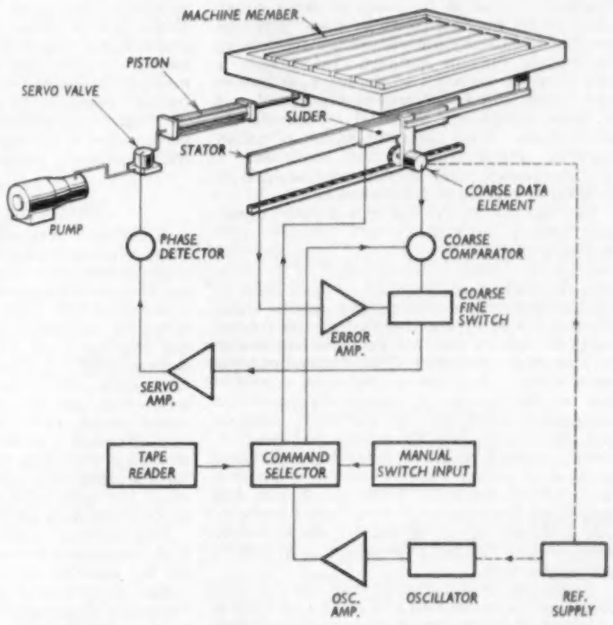


Fig. 34—Diagram of Sperry point-to-point positioning control system employing both analogue and digital techniques

The positioning control accepts programmed command information from standard one-in-eight-channel tape. This tape may be prepared on any standard automatic punch in binary coded decimal form which is recognised by the tape reader. The reader reads blocks of information instantaneously and thereby eliminates the need for a complex and costly shift register which would normally store information registered by sequential line-by-line readers as used in conventional control systems. A block of information consists of 2in of tape and contains all command details pertaining to one-hole position. The control system may also be supplied with manual input controls for use in instances where tape programming is considered unnecessary, such as in certain "one off" jobs. Manual input is provided in the form of a bank of decade switches for each controlled axis, which can be set to the correct command dimensions by the operator.

The measuring element of the system (Fig. 34) translates linear or rotary measurements into electrical equivalents which can be recognised by the control system, using very precise linear transducers. These transducers consist of slabs of a glass-mica compound with a coefficient of expansion closely approximating that of steel. This compound is very tough and stands up well under industrial conditions. The slabs have plated on them a series of fine lines in the shape of an elongated hairpin coil.

The transducer consists of two major components: (1) the stator is made up of sufficient sections aligned end to end, to cover the required travel length of the controlled axis. Each section is series-connected to its neighbour, thus forming one long continuous coil. (2) The slider consists of only one section similar to a stator section, but has plated on it a series of separate coils, each coil covering about 0·25in. The slider is rigidly linked to the moving machine member and rides over the stator. There is a clearance of a few thousandths of an inch between the two and, therefore, no mechanical wear is introduced.

Low frequency a.c. excitation of any coil on the slider will induce an approximately sinusoidal signal in the stator coil. This signal will be at full amplitude when the turns in the energised slider coil are exactly aligned with the stator coil, and the signal will fall off to a null when the two coils are exactly misaligned. Each coil in the slider is separated from the next by a given distance, less 0·001in progressively. Thus, it can be seen that null points may be electrically shifted by increments of 0·001in by selecting appropriate slider coils. A simple interpolator circuit further resolves this dimensional quantity into the parts or ten thousandths of an inch. Due to the fact that each slider coil consists of several contributing turns, and the output signal at the stator is the vector sum of all turns, any local plating errors are averaged out to a large extent.

In practice, a coarse data element geared to a small rack mounted parallel to the machine motion, is used to bring the member to within about 0·050in of desired position. Pre-selection of an appropriate slider coil establishes a null at the desired final position, and the member is now driven from the end of the coarse travel, 0·050in away, in fine travel to this null. Electronic switching brings the fine measuring system into play at the appropriate point. An accuracy of ±0·0005in and repeatability of ±0·0001in can be achieved with this method over all conventional travel lengths.

The linear transducers measure accurately, irrespective of the condition or type of transport mechanism. They are consequently unaffected by such phenomena as screw windup, back lash, high spots and dirt. They can be used to great advantage with hydraulic piston drives without the necessity for linear-to-rotary conversion. The digital coil selection technique employed in the fine measuring phase does away with the need for critically balanced and calibrated analogue circuitry and ensures positive positioning, without drift problems. Economical and conventional analogue circuitry is used in the non-critical coarse measuring phase.

The Bendix Corporation

The Bendix Industrial Controls Section, of Detroit, Michigan, exhibited its "Dynapath" numerical contouring system applied to a three-spindle, three-axis, Pratt and Whitney Keller profiling machine. The control unit utilises punched, plastics tape to store the machine

THE AMERICAN SCENE *(Continued)*

control data. Information on the tape is translated by the machine control unit into commands to electro-hydraulic servo drives for each of the various machine, spindle and table motions. Feedback devices in the form of either rotary resolvers on the leadscrews or linear resolvers attached to the slides and ways accurately measure the various machine motions. Information is sent from the resolvers to the machine control unit where differences between command and feedback signals are amplified to operate the servo-drives. With the combination of rotary resolvers, precision gears and leadscrews, a machine control until resolution of as little as 0·000025in is being accomplished.

The machine control unit is a compact design that utilises the transistorised circuitry with modular plug-in construction. This provides low power consumption and ease of maintenance for continuous operation. Signal lights in the machine control unit indicate trouble areas. Checking features are provided in the control panel to indicate that the electronic equipment is operating correctly. The electro-hydraulic servo drives, which are a substantial contribution to the success of numerically controlled contouring operations, are extremely compact and can be easily adapted to any machine tool. They combine stiffness with high dynamic response to obtain accurate control of position and rate of motion. Thus the system can provide accurate contours with smooth surfaces. The hydraulic power supply for the hydraulic servo systems operates at pressures up to 3000 lb per square inch.

A manual control that permits the operator to reduce the cutter feed rate at any time down to as little as 20 per cent of the tape-programmed rate is included in the machine control system. This permits the operator to reduce the cutter feed to accommodate such variables as cutter quality or material hardness. Thus maximum tool life and surface finish can be achieved without re-making a tape to provide reduced tool loading in critical work areas. If unusual tool dulling or work hardness cause the difference between command and actual positions to exceed a preset amount, synchronisation circuitry causes automatic machine shutdown. This feature reduces cutter breakage, ensures maximum work accuracy and avoids scrapping of a workpiece.

It is possible to make symmetrical or mirror-image parts with the system by programming only half or quarter of the complete process. Reversing switches provided for each axis enable the machine motion to be the reverse of that which has been programmed on the tape. With this arrangement, it is only necessary to set up one quadrant of a part symmetrical about the X and Y axes. To facilitate synchronisation of absolute cutter position with the tape during set-up or after interruption of the cut, special circuits are provided to capture and lock-in the machine tool elements when brought manually to within ±0·050in of the programmed location. Such auxiliary machine functions as coolant flow, chip conveyor operation, tool changes, table index and spindle speed change can be programmed into the tape to provide them automatically, independent of operator control.

When equipped with the circular interpolation option, the control unit will direct the machine to cut arcs or complete circles in addition to straight lines. In order to generate arcs and circles, it is only necessary to punch on the control tape the starting point, and the end point of the circular section as well as the direction of cut. Normally the "Dynapath" system generates straight line machine movements between points programmed on the tape. If a part shape is made up of a series of straight lines and circular arcs, the interpolation unit can reduce the computer time required to make a control tape.

Because of the circular interpolation feature and the binary-coded decimal tape format, computations are minimised—even to the point where tapes can be prepared or modified for some parts without the use of a computer. The first step in preparing a tape is writing a process sheet from information contained on the numerical part drawing and additional data on cutter geometry, feed rates, auxiliary functions, &c. If the part is made up of straight lines and circular arcs, the control tape, describing the tool centre path, can be punched directly from information on the process sheet. For more complex parts, a process tape or punched cards are prepared to transmit the information on the process sheet to a computer, which then produces the eight-channel control tape.

Specialties, Incorporated

A different approach to numerical machine control has been taken by Specialties, Incorporated, Syosset, New York. Instead of developing the system for programming and tape preparation away from the shop, this system is designed to permit complete set-up and programming at the machine. At Chicago, the system was demonstrated on a Jones and Lamson turret lathe (Fig. 35). The system is designed for short runs, and set-ups can be completed in approximately half the time required on conventional turret lathes. On many parts production is more than doubled when turret lathes incorporating this new control are used. In effect, the turret lathe is converted into a single-spindle automatic for short runs.

Point-to-point rectilinear control of feed rates and dimensional end points at the control panel on the machine tool, together with a built-in logical programming system, enables the set-up man to work directly from the numerical dimensions on the blueprint. The outstanding characteristic of this so-called "Specialmatic" method is that the know-how of the operator can be combined, at the machine tool, with the speed of set-up and operation offered by numerical control. The control systems are readily adapted to turret lathes, boring machines, grinders, welders, flame-cutters, and drilling machines.

Instead of tape or cards used for programming, a complete set of stainless steel keys is supplied with each system. In this programming method, each key in a set is pre-perforated in a binary pattern by the firm to provide logical control of up to three operations or auxiliary functions. For a required set-up, the correct keys to programme the necessary sequence of operations are selected from the set and inserted in a programming drum which is mounted in the control panel. The perforation patterns in the keys are read into the system by photo-electric cells. Because there are places for thirty-six keys on the reader, a possible 108 operations of sixty-three different types are provided and may be used in any desired sequence. With the functional sequence programmed, end points and feed rates are individually set for each required dimension by one of the dials on the control panel. For example, a turret lathe can be programmed by twelve to sixteen dials on the turret; the number of dials can be varied according to machine requirements. The turret has sixteen positioning dials available, while the cross-slide and carriage each have eight dials. In only a few minutes, the drum is programmed and rough dial settings are made. Then, with tools and work in place, the set-up man makes a trial cut on each operation. Any correction or adjustment which appears necessary after inspection of this piece can be made by dialling in the correction on the dial which controls the in-point for that dimension.

The heart of the control system is a new sequential, linear-positioning transducer, which provides infinite resolution. Its positioning repeatability is about 0·0002in under shop conditions for most applications. Each controlled motion is fitted with one of these transducers, to feed back a signal which reports its position at all times. Numerical input to the control is by the individual dials. Each dial controls two smaller input transducers: a coarse-positioning digital device gives approximate position of cut and a fine-positioning unit, used as a vernier, provides in-point adjustment. The dials are calibrated in divisions of 0·001in, and settings to 0·0001in are readily made by interpolating within divisions. The feed rate is controlled by a knob in the centre of each dial.

Linear measurement is achieved by balancing the signal from the controlled-motion transducer with the signal set-up by the input transducers when the desired end point is dialled. The selection of the direction and position of the measurement dialled on the panel is determined by the sequence programmed by the arrangement of keys in the drum-reader. A lamp in the centre of each dial lights to show when that dial is in control of a motion.

(To be continued.)

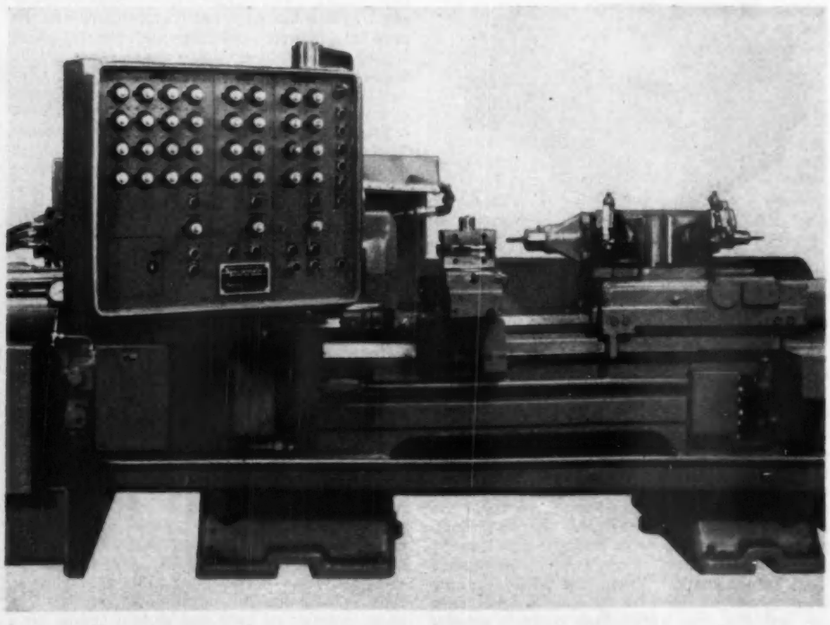


Fig. 35—Jones and Lamson turret lathe equipped with "Specialmatic" numerical control system

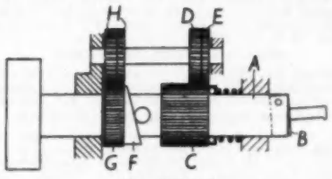
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MACHINE TOOLS

852,292. February 6, 1957.—SCREW-CUTTING STATIONARY WORKPIECES, Johannes Guido, Borsigstrasse No. 13, Regensburg-Neutraubling, Germany.

The object of the invention is to provide a screw-cutting machine which permits economical manufacture with the highest possible cutting speed and the production of very long screw threads. According to the invention the cam disc for the feed drive is rotatable concentrically to the tool shaft but is axially non-displaceable, and acts directly on the tool shaft or on a part fixed thereto. The cam disc is driven at a speed which is proportional to the speed of the tool shaft but is not identical to it. The drawing shows a diagrammatic longitudinal sectional view through the axes of the tool shaft and countershaft of such a mechanism used for internal threading.



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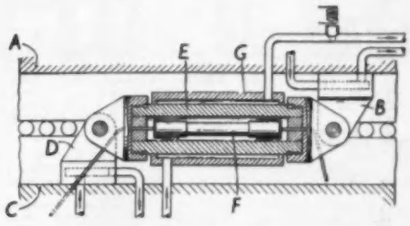
The tool shaft *A* carries at its rear end a driving belt pulley and at the front end a toolholder *B*, the toolholder being pivotable about a pin in a slot in the tool shaft. A gearwheel *C* mounted on the tool shaft drives two gearwheel sections *D E* having the same number of teeth and which are mounted on a countershaft. Only one section *D* rotates with the countershaft, the section *E* being free. The two gearwheels are held resiliently against one another by springs (not shown) in such a manner that tooth play in the drive of the countershaft is eliminated, and lifting of the teeth upon changes in load is prevented. The drive of a cam disc *F*, which is provided with external teeth *G*, from the countershaft through gearwheel sections *H* is arranged in the same manner. The surface of the cam disc co-operates with a pin or a roller fixed in the tool shaft on which the disc is mounted independently. The tool shaft is held by a compression spring to press the pin against the cam surface and rotation of the cam disc with respect to the tool shaft displaces the shaft in the axial direction. When the tool shaft is driven, the cam disc is rotated at a speed which differs only slightly from that of the shaft. The ascending portion of the cam surface displaces the tool shaft towards the right in opposition to the action of the spring with the requisite amount of thread-cutting feed (pitch), and in this operation a first fine cut is made along the workpiece. When the right-hand end position is reached, the pin moves on a plane portion of the cam and there is no axial movement of the tool shaft. The toolholder is then pivoted about the pin by a known device to move its point out of the cut. During movement of the pin on a subsequent descending portion of the cam, the tool shaft is moved backwards at an increased speed by the spring. At the rearmost point of this movement, the toolholder is pivoted in the clockwise direction to the desired increased depth of cut. This cycle is repeated until the whole of the thread is cut.—*October* 26, 1960.

852,147. November 19, 1958.—DEVICE FOR FEEDING THE TOOL IN MACHINE TOOLS, Fortuna-Werke Spezialmaschinenfabrik A.G., Stuttgart-Bad Cannstatt, Germany.

The invention relates to a method and a device for effecting very fine feed movements of tools, and in particular on grinding machines. There is provided a feed member consisting of a rigid expansion bar, connected without play between the tool carriage and the base member, and provided with heating and cooling means. This feed bar damps the machine tool vibrations, but produces a feed by its expansion when heated. The method of thermal feed consists in that after the termination of the usual quick operation and/or coarse feed the feed bar is heated and feeds the tool carriage towards the workpiece by its slow expansion. When the workpiece has reached its designed dimension, the heat supply is switched off and the bar is cooled, the quick return movement of the tool carriage being switched on at the same time. By regulating the amount of heat supplied per unit of time feed magnitude and feed characteristic can be adjusted. In the accompanying drawing one embodiment of



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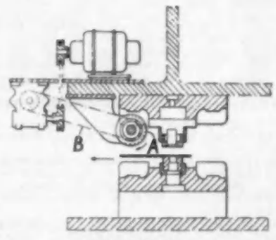
the device is illustrated by way of example. On the tool carriage *A* a bracket *B* is fixed and on the base member *C* a corresponding bracket *D*. A hollow expansion bar *E* carries at its ends forked bearings connected to the expansion bar. The bore of the expansion bar is closed at its ends by sealing plugs and contains a ceramic heating rod *F* mounted on insulating rings. The expansion bar is surrounded by a cooling jacket *G*. By means of a hydraulically or electro-magnetically operated valve, the timing for the flow of the coolant through the device is controlled, and likewise the beginning, ending, intensity and changes in intensity of the electric current for the heating device may be controlled by adjustable hydraulically or electrically-operated switches operated in connection with the automatic control of the machine. The cooling of the bases of the brackets prevents any undesirable transfer of heat into the tool carriage and base member, respectively.—*October* 26, 1960.

852,319. May 11, 1959.—PRESSES, Société Générale de Constructions Électriques et Mécaniques (Alsthom), 38, Avenue Kleber, Paris, France.

The invention relates particularly to means for removing magnetic work from press brakes. The accompanying drawing shows a cross section of the press. The workpiece to be moved is attracted by a series of magnetic rollers *A* fixed along a shaft, which is supported by the vertically movable slide of



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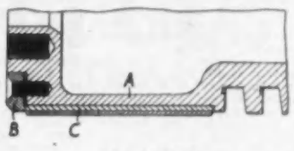
the press. The roller shaft is driven by an electric motor through gearing and a chain *B*. After the metal working operation has been performed, the rollers magnetically grip the workpiece which is driven towards the stacking or other receiving device (not shown) at the delivery side. The number of rollers can be selected in accordance with the dimensions and weight of the piece to be removed.—*October* 26, 1960.

ENGINES

852,558. May 7, 1959.—PISTON AND PISTON-RING ASSEMBLIES, Glacier Metal Company, Ltd., 368, Ealing Road, Alperton, Wembley, Middlesex. (*Inventor: Reginald John Charlesworth Whitaker.*)

This invention relates to assemblies for use where the piston-ring is intended to act as a bearing member against the walls of a cylinder such as in free piston engines or in reciprocating compressors or pumps. One embodiment is described by way of example with reference to the accompanying drawing showing a sectional side elevation through a piston and bearing piston-ring construction. The piston skirt *A* is formed with an annular recess having an undercut shoulder at one end and a detachable keeper ring *B* which is secured to the end of the main body, this ring also having an undercut flank surface. The recess together with the keeper ring thus forms an annular groove with opposed undercut flank surfaces surrounding the skirt of the piston. A bearing ring *C*, secured within this recess, comprises a number of separate curved segments. Each bearing ring segment is of multi-layer construction and comprises a steel backing with a layer of a bearing material



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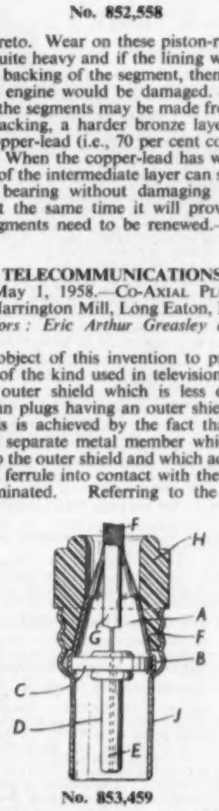
applied thereto. Wear on these piston-ring segments could be quite heavy and if the lining wears through to the steel backing of the segment, then the cylinder wall of the engine would be damaged. In order to avoid this, the segments may be made from tri-metal, i.e., steel backing, a harder bronze layer and a top lining of copper-lead (i.e., 70 per cent copper, 30 per cent lead). When the copper-lead has worn through the bronze of the intermediate layer can still act as an emergency bearing without damaging the cylinder wall and at the same time it will provide warning that the segments need to be renewed.—*October* 26, 1960.

TELECOMMUNICATIONS

853,459. May 1, 1958.—CO-AXIAL PLUG, Pressac, Ltd., Harrington Mill, Long Eaton, Nottingham. (*Inventors: Eric Arthur Greasley and Graham Kirk.*)

It is an object of this invention to provide a co-axial plug, of the kind used in television equipment, having an outer shield which is less expensive to produce than plugs having an outer shield of turned metal. This is achieved by the fact that the usual second and separate metal member which normally screws on to the outer shield and which acts to engage and force a ferrule into contact with the outer braid can be eliminated. Referring to the drawing, a



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tapered metal sleeve *A* has its larger diameter end formed with a flange or collar *B* which is of shallow cup-like form in cross section so that it can receive an insulating disc *C* carrying the centre pin *D* of the plug, the edge of the cup-shaped flange being beaded or deformed over against the outer face of the insulating disc. The inner core *E* of the cable passes through the centre pin *D* of the plug which extends from one side of the insulating disc, and the sleeve *A* which extends from the other side of the disc engages in between the outer braiding *F* of the cable and the insulating materal *G* which surrounds the centre core, the upper end of the sleeve being formed with slits to form tongues which grip the insulating material. The cable is fitted with an external ferrule *H* of plastic material which bears against one side face of flange *B* and the threaded end of this ferrule is engaged by a larger diameter part of an outer metal shield *J* which is drawn, i.e. not machine turned, and which is thread rolled, the shield comprising a smaller diameter part which surrounds the centre pin and is concentric therewith. As the shield is screwed on to the ferrule the shoulder between the two different diameter parts of the shield abuts the beaded-over face of the flange *B* of the tapered sleeve *A* and as the shield is screwed home the shoulder presses on the flange and causes the tapered sleeve to be forced inside the outer braiding of the cable whereby the braiding is flared and tightly gripped and trapped between the sleeve and the inner face of the ferrule so that the braid accepts any pull which is exerted on the cable and this pull is not transmitted to the centre core. The electrical connection between the braid and the outer metal shield *J* is by way of the metal tapered sleeve *A* and the flange *B* and then on to the shoulder of the shield *J* where the latter contacts the beaded-over portion of the flange which holds the insulating disc *C* for the centre pin *D* in position.—*November* 9, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 25.—COVENTRY AND DISTRICT BRANCH : E.M.E.B. Sports and Social Club, Merrick Lodge, Sandy Lane, Coventry, "A History of Tape Recording," G. Dawson, 7.30 p.m.

Mon., Nov. 28.—NORTH WEST LONDON BRANCH : Compass Hotel, Watford, "Electrical Aspects of Process Control," W. C. Hankins, 7.45 p.m.

Thurs., Dec. 1.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, Sussex, "Stage Lighting Presentation," F. E. Brown, 7.30 p.m. ★ OXFORD AND DISTRICT BRANCH : Cockcroft Hall, Harwell, "Circuit and Equipment Applications of Transistors," 5.45 p.m.

Fri., Dec. 2.—LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, "An Approach to the Use of Electrical Units," D. Chalmers, 7.30 p.m. ★ STOKE AND CREWE BRANCH : Royal Hotel, Crewe, "Variable Speed A.C. Motors," J. C. H. Bone, 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Thurs., Dec. 1.—Connaught Rooms, Great Queen Street, London, W.C.2, One-day conference on "The Importance of Engineering Services to Modern Management," 9.15 a.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Dec. 1.—NORTH WESTERN SECTION : Reynolds Hall, College of Technology, Manchester, "Industrial Television", I. M. Waters, 7 p.m.

Fri., Dec. 2.—COMPUTER GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Progress in Microminiature Circuit Techniques for Digital Computers," D. Roberts, D. S. Campbell, and P. M. Thompson, 6.30 p.m. ★ SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, "The Place of the Electric Rocket in Space Propulsion," W. A. S. Murray, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Sat., Dec. 3.—Tudor Room, Caxton Hall, London, S.W.1, "The History and Future of Telescopes for Astronomical Observations," H. C. King, 6 p.m.

BRITISH PLASTICS FEDERATION

Wed. to Fri., Nov. 30 *to Dec.* 2.—REINFORCED PLASTICS GROUP : Cafe Royal, London, Second International Reinforced Plastics Conference, 9.15 a.m. each day.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 28.—BIRMINGHAM CENTRE : Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Production of Light Sources," H. R. Ruff, 6 p.m.

Thurs., Dec. 1.—NOTTINGHAM CENTRE : Electricity Centre, Carrington Street, Nottingham, "The Eye and Artificial Lighting," W. J. Wellwood Ferguson, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Nov. 30.—SOUTHAMPTON SECTION : Technical College, St. Mary's Street, Southampton, "Running and Gating of Castings," W. W. Glick, 7.30 p.m.

Thurs., Dec. 1.—LONDON BRANCH : 17, Belgrave Square, London, S.W.1, Joint meeting with the Institute of Metals, London Local Section, "Origin, Detection and Elimination of Gases in Cast Metals," D. V. Atterton, 6.30 p.m.

INSTITUTE OF MATERIALS HANDLING

Wed. Nov. 30.—SOUTH YORKSHIRE SECTION : Dorchester Suite, Grand Hotel, Sheffield, One-day conference on "Top Management Takes a New Look at Materials Handling," 9.30 a.m.

INSTITUTE OF METALS

Tues., Nov. 29.—OXFORD LOCAL SECTION : Cadena Café, Cornmarket Street, Oxford, Junior Members' Evening, 7.15 p.m.

Thurs., Dec. 1.—LONDON LOCAL SECTION : 17, Belgrave Square, London, S.W.1, Joint meeting with the Institute of British Foundrymen, "The Origin, Detection and Elimination of Gases in Cast Metals," D. V. Atterton, 6.30 p.m. ★ LIVERPOOL METALLURGICAL SOCIETY : Department of Metallurgy, The University, Liverpool, "Low Temperature Brazing," H. R. Brooker, 7 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Dec. 1.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, "Positive Displacement Rotary Compressors as Applied to Refrigeration," E. J. Perry, and P. D. Laing, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Nov. 28.—SCOTTISH CENTRE : North British Hotel, Edinburgh, "Vehicle Engine Cooling System Operation and Techniques Developed to Minimise Maintenance Cost," S. J. H. Dyson, 7.30 p.m.

Thurs., Dec. 1.—WESTERN CENTRE : Royal Hotel, Bristol, "Transport in Tripolitania," H. L. Lyons-Jones, 7 p.m.

Mon., Dec. 5.—MANCHESTER AND DISTRICT CENTRE : Fairbairn Room, Engineers' Club, Albert Square, Manchester, "The Future of Road Transport," A. Enticknap, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 29.—Great George Street, Westminster, London, S.W.1, Symposium on "Management," Sir Leonard Owen, J. F. Baker, Sir Ewart Smith, and S. M. Lovell, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Nov. 26.—LONDON GRADUATE AND STUDENT SECTION : Visit to Strand Electric and Engineering Company, Ltd., 2.30 p.m.

Mon., Nov. 28.—ARBORFIELD DISTRICT MEETING : Unit Cinema, 3 (Tels.) Training Bn., R.E.M.E., Arborfield, Berks., Film Evening, 7 p.m. ★ EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Training for Research," opened by G. H. Rawcliffe and G. A. V. Sowter, 6 p.m. ★ EAST ANGLIAN SUB-CENTRE : Electric House, Ipswich, "An Introduction to Electronic Computers," R. C. M. Barnes, 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Royal Institution, Colquitt Street, Liverpool, "Thermistors—Their Theory, Manufacture and Application," R. W. A. Scarr, and R. A. Setterington, 6.30 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP : James Watt Memorial Institute, Birmingham, "Static Switching," G. L. Butcher, 6 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : Mechanical Institute, Crewe, "A Survey of Street Lighting and its Future," W. R. Stevens and H. M. Ferguson, 7 p.m. ★ WESTERN UTILISATION GROUP : S. Western Electricity Board Lecture Theatre Centre, Bristol, "Discrimination between H.R.C. Fuses," E. Jacks, 6 p.m.

Tues., Nov. 29.—SOUTH EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "Submersible Pumping Plant," H. H. Anderson and W. G. Crawford, 7 p.m.

Wed., Nov. 30.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "The Potentialities of Artificial Earth Satellites for Radiocommunication," W. J. Bray, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to C.E.G.B. Kingston "B" Generating Station, 10.30 a.m. ★ NORTH EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Hovercraft," D. J. Hardy, and "M.I.," F. T. Jones, 7 p.m. ★ SHEFFIELD SUB-CENTRE : Grand Hotel, Sheffield, Joint meeting with the Sheffield Graduate and Student Section, Discussion on "The Education and Training of a Professional Electrical Engineer," 6.30 p.m. ★ RUGBY SUB-CENTRE : College of Technology and Arts, Rugby, Joint meeting with the Rugby Graduate and Student Section, "Electricity in Medicine," W. J. Perkins, 6.30 p.m.

Thurs., Dec. 1.—ORDINARY MEETING : Savoy Place, London, W.C.2, "Our Civic Lighting : Gloom or Gaiety," and "A Survey of Street Lighting and its Future," W. R. Stevens and H. M. Ferguson, 5.30 p.m. ★ NORTH MIDLAND CENTRE : Lecture Theatre, Y.E.B. Offices, Ferensway, Hull, Joint meeting with the Graduate and Student Section, "Marine Electrical Practice on Cargo Liners," D. G. Robinson, 6.30 p.m. ★ SOUTHERN CENTRE : South Dorset Technical College, Weymouth, "Instrumentation of Nuclear Reactors," D. Harrison, 6.30 p.m.

Fri., Dec. 2.—MEDICAL ELECTRONICS DISCUSSION GROUP : Savoy Place, London, W.C.2, Discussion on "Telemetering Biological Data," opened by G. H. Byford and K. G. Williams, 6 p.m.

Mon., Dec. 5.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "National Proving of Domestic Electrical Equipment," opened by C. A. Zweigbergk, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Royal Institution, Colquitt Street, Liverpool, "The Determination of the Electrical Characteristics of an Arc Furnace," J. Ravenscroft, 6.30 p.m. ★ NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP : Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, "Radar Observations of Birds and 'Angels,'" E. Eastwood, 6.15 p.m. ★ SOUTH MIDLAND CENTRE : College of Technology, Birmingham, Combined Meeting with the Electronics and Measurement and the Supply and Utilisation Groups and the Birmingham Centre of the J.P.O.E.E., "Radiocommunication in the Power Industry," E. H. Cox and R. E. Martin, 6.30 p.m. ★ SOUTH MIDLAND CENTRE : Winter Gardens, Great Malvern, "Parametric Amplifiers," R. V. R. Carter and I. A. Bagnall, 7.30 p.m. ★ MAIDSTONE BRANCH : Technical College, Maidstone, "Uses and Manufacture of N.I.C.C. Cable," G. E. D. Redman, 7 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Thurs., Dec. 1.—LONDON BRANCH : 38, Portland Place, London, W.1, "The Development of Centreless Grinding Techniques," A. E. Adams, 7 p.m.

Mon., Dec. 5.—NORTH-EAST BRANCH : New Lecture Theatre, Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, 1, "Inventions, Patents and the Engineer," C. P. MacCarthy, 7.15 p.m. ★ NORTH STAFFORDSHIRE BRANCH : North Staffordshire Technical College, Stoke-on-Trent, "Electronic Computers," J. Boothroyd, 7.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 29.—39, Elmbank Crescent, Glasgow, Informal Meeting, "Does Prefabrication Pay ?" 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Nov. 25.—NORTHERN BRANCH : Union Hall, Whitehaven, "Bridges in the West Riding, with particular reference to the Wentbridge Viaduct," N. H. Buchi, 7 p.m. ★ NORTH EASTERN BRANCH : University of Durham Science Laboratories, Durham City, "Highway Design," W. S. Hydes and A. W. Jacomb, 7 p.m.

Fri., Dec. 2.—LONDON BRANCH : Institution of Structural Engineers 11, Upper Belgrave Street, London, S.W.1, "Lessons Learned on the Design and Construction of Motorways—(ii) From the Consultant's Angle," R. F. Earley, 5.30 p.m. ★ NORTH EASTERN BRANCH : Appleby Theatre, University of Durham Science Laboratories, South Road, Durham City, "Highway Design," W. S. Hydes and A. W. Jacomb, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 25.—NORTH EASTERN GRADUATES' SECTION : Rutherford College, Newcastle upon Tyne, "Photoelasticity," R. Stead, 6.30 p.m.

Mon., Nov. 28.—YORKSHIRE BRANCH : Afternoon visit to Hepworth and Grandage, Bradford : Institute of Technology, Bradford, "Planned Maintenance," W. Jones, 7.15 p.m. ★ SOUTHERN GRADUATES' SECTION : All-day visit to Vauxhall Motors, Ltd., Luton.

Tues., Nov. 29.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Gear Materials and their Treatment," 6 p.m. ★ BIRMINGHAM A.D. CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, Repetition of A.D. Chairman's Address, "Milestones in the Life of an Automobile Engineer," W. M. Heynes, 6.30 p.m. ★ SOUTH WALES BRANCH : South Wales Institute of Engineers, Cardiff, Repetition of the James Clayton Lecture, "The Future of Air-breathing Engines in Aviation," S. G. Hooker, 6 p.m. ★ EASTERN GRADUATES' SECTION : Old Manor House, St. Margarets Green, Ipswich, Film Show, 7.30 p.m.

Wed., Nov. 30.—ORDINARY MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "Economic Results of Diesel-Electric Motive Power on the Railways in the United States of America," H. F. Brown, 6 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : College of Technology, Infirmary Road, Chesterfield, "The Measurement of Surface Strain," R. W. Wilson, 7.15 p.m. ★ LONDON GRADUATES' SECTION : Wimbledon Technical College, Gladstone Road, London, S.W.19, "The Design of the N.P.L. Standard Hardness Test Machines," F. C. P. Mason, 7 p.m. ★ NORTH EASTERN GRADUATES' SECTION : Visit to Wilton Works, I.C.I., Ltd., 6.15 p.m.

Thurs., Dec. 1.—EDUCATION GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Is Training in Industry really Integrated with Academic Studies on Sandwich Courses in Colleges of Technology," 6 p.m. ★ SOUTHERN BRANCH : King and Queen Hotel, Brighton, "Water Supply," F. N. Green, 7.15 p.m.

Fri., Dec. 2.—EASTERN GRADUATES' SECTION : College of Further Education, High Wycombe, Film Show, 7.30 p.m.

Mon., Dec. 5.—NORTH EASTERN BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, "The Diesel Engine in Association with the Gas Turbine," E. Chatterton, 6 p.m.

INSTITUTION OF PLANT ENGINEERS

To-day, Nov. 25.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "British Railways Electrification Scheme," W. B. Marrian, 7.30 p.m.

Mon., Nov. 28.—WEST AND EAST YORKSHIRE BRANCH : Houldsworth School of Applied Science, The University, Leeds, "The Building of a Modern Oil Tanker," W. S. Brown, 7.30 p.m.

Tues., Dec. 6.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Civil Engineering Problems in Tall Buildings," Sir Thomas P. Bennett, 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 25.—NORTH MIDLANDS REGION : Louis Room, St. James Restaurant, St. James Street, Derby, "Developments in Dimensional Accuracy," K. J. Hume, 7 p.m.

Mon., Nov. 28.—NORTH WESTERN REGION : Reynolds Hall, Manchester College of Science and Technology, Manchester, "Machine Tool Development as Seen at Olympia, 1960," Norman Stubbs, 7.15 p.m. ★ EAST AND WEST RIDINGS REGION : Grand Hotel, Grosvenor Room, Sheffield," "Membership Qualifications," H. W. Hodson, 6.30 p.m.

Wed., Nov. 30.—MIDLANDS REGION : Walker Technical College Oakengates, Shrewsbury, "Recent Developments in High Production Foundries," J. D. Berry, 7.30 p.m.

Thurs., Dec. 1.—SOUTH EASTERN REGION, ROCHESTER GRADUATE SECTION : Old Palace, Maidstone, "Diamond Wheels as Applied to Carbide Tool Production," J. C. Dawkins, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Nov. 28.—MANCHESTER SECTION : Engineers' Club, Albert Square, Manchester, "Casting in the Rubber Industry," G. P. Slater, 6.45 p.m.

Mon., Dec. 5.—BURTON-ON-TRENT SECTION : Midland Hotel, Station Street, Burton-on-Trent, "Modern Methods in Compounding Neoprene," A. Fiber, 7.30 p.m. ★ NORTH EASTERN SECTION : Eldon Grill, Newcastle, "Footwear," F. Baynes, 7 p.m. ★ SOUTH WALES AND MONMOUTHSHIRE SECTION : Queens Hotel, Newport, "Chemical Resistance of Rubbers and Plastics," B. J. Habgood, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 25.—MIDLAND COUNTIES BRANCH : Byng Kendrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 6, "The Architect and the Developer," J. Seymour Harris, 6.30 p.m.

Wed., Nov. 30.—MERSEYSIDE PANEL : College of Building, Clarence Street, Liverpool, "Some Unusual Aluminium Structures," W. Hamilton, 6.30 p.m.

Fri., Dec. 2.—WESTERN COUNTIES BRANCH : Small Lecture Theatre, University Engineering Laboratories, University Walk, Bristol, 8, "The Characteristics of Friction Grip Bolt Joints," M. S. G. Cullimore, 6 p.m.

IRON AND STEEL INSTITUTE

Wed. to Fri., Nov. 30 *to Dec.* 2.—Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, Symposium on "Steels for Reactor Pressure Circuits," 9.30 a.m. each day.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 25.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

Fri., Dec. 2.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, "Dounreay Fast Reactor," "More for Your Money," and "Isotopes in Industry," 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Mon., Dec. 5.—Mining Institute, Newcastle upon Tyne, "The Effect of Wave Form and Wavelength on Bending Moment," J. F. C. Conn, and N. S. Miller, 6.15 p.m.

PLASTICS INSTITUTE

Tues., Nov. 29.—Empire Restaurant Hall, Olympia, London, Symposium on "Plastics and Corrosion," 2.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Dec. 1.—LONDON BRANCH : 11, Upper Belgrave Street, London, S.W.1, "Reinforced Concrete Construction in the Coal Industry," C. A. C. Davies, 6 p.m.

Mon., Dec. 5.—NORTH-WESTERN BRANCH : College of Technology, Sackville Street, Manchester, "A Report on the Cement and Concrete Association's Visit to South America," D. D. Matthews, and J. L. Womersley, 6.45 p.m.

ROYAL AERONAUTICAL SOCIETY

Mon., Nov. 28.—Library, 4, Hamilton Place, London, W.1 "The Farmer's Viewpoint," J. B. Farrant, 7 p.m.

Tues., Nov. 29.—Library, 4, Hamilton Place, London, W.1, "The Design of Ground Effect Machines," R. Stanton Jones, 6 p.m.

Wed., Nov. 30.—Library, 4, Hamilton Place, London, W.1, "Some Aspects of Bird Flight," John Barlee, 7 p.m.

Thurs., Dec. 1.—LUTON BRANCH, MAIN LECTURE : Assembly Hall, Luton High School, Alexandra Avenue, Luton, "Ballistic Research Rockets, with particular reference to Black Knight," D. J. Lyons, 6.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Sat., Nov. 26.—MINING SURVEYORS GENERAL MEETING : Welbeck Hotel, Nottingham, "Offshore Mineral Exploration," R. H. Garnett, 10.30 a.m.

ROYAL INSTITUTION OF NAVAL ARCHITECTS

Thurs., Dec. 1.—10, Upper Belgrave Street, London, S.W.1, "Strength of Propellers," J. E. Conolly, 4.45 p.m.

ROYAL SOCIETY

Wed., Nov. 30.—Burlington House, London, W.1, Anniversary Meeting, 2.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Nov. 30.—John Adam Street, Adelphi, London, W.C.2, "Some Traffic Problems of London," A. Samuels, 6 p.m.

ROYAL STATISTICAL SOCIETY

Wed., Nov. 30.—SHEFFIELD GROUP : Grand Hotel, Sheffield, 1, "New Uses of Computers in Statistics," G. A. Barnard, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Dec. 1.—CORROSION GROUP : Empire Restaurant, Olympia London, W.14, "The Influence of Water Movement on Corrosion," 2 p.m. and 3.45 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Nov. 25.—SCOTTISH SECTION : The University, Glasgow, "Instrumentation of a Space Vehicle," A. E. Roy, 7.15 p.m.

Tues., Nov. 29.—DATA PROCESSING SECTION : Manson House, 26, Portland Place, London, W.1, Symposium on "Nuclear Temperature Scanning," 6.30 p.m.

Wed., Nov. 30.—SOUTH WALES SECTION : Welsh College of Advanced Technology, Cardiff, "The Application and Selection of Automatic Control Valves," P. Stone, 6.45 p.m.

Fri., Dec. 2.—FAWLEY SECTION : Administration Building, Esso Refinery, Fawley, "Selection, Design and Application of Automatic Control Valves," P. Stone, 5.30 p.m.

Mon., Dec. 5.—SOUTH YORKSHIRE SECTION : University, St. George's Square, Sheffield, 1, "Instrumentation for Railway Research," P. H. Mansfield, 7 p.m.

STANDARDS ENGINEERS SOCIETY

Tues., Nov. 29.—UNITED KINGDOM SECTION : British Standards House, 2, Park Street, London, W.1, General meeting, 4 p.m.

TELEVISION SOCIETY

To-day, Nov. 25.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, "Measurement Techniques for Television Broadcasting," L. E. Weaver and I. J. Shelley, 7 p.m.

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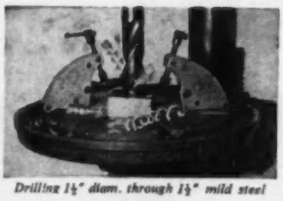

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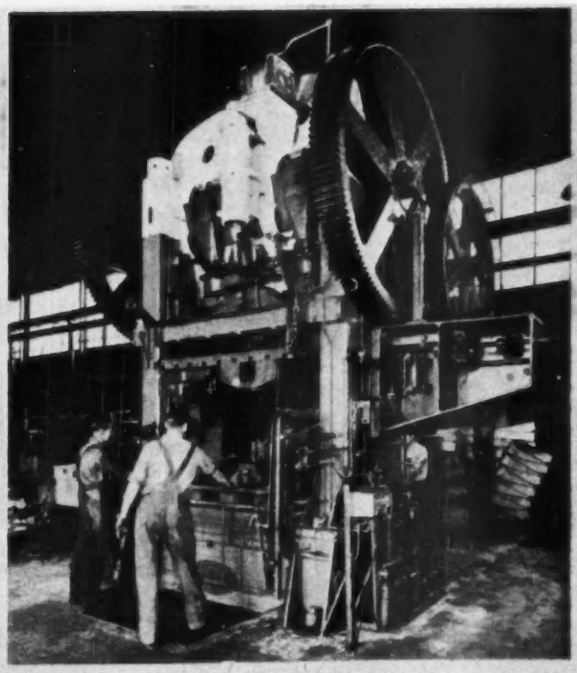

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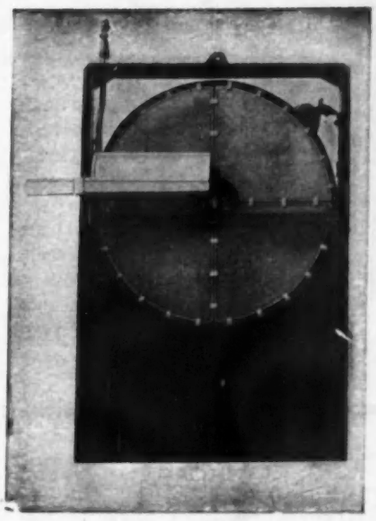

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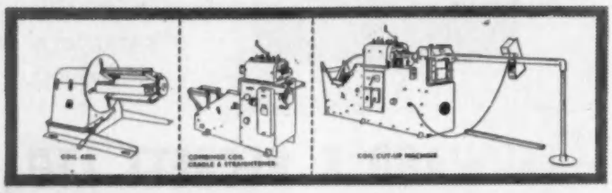

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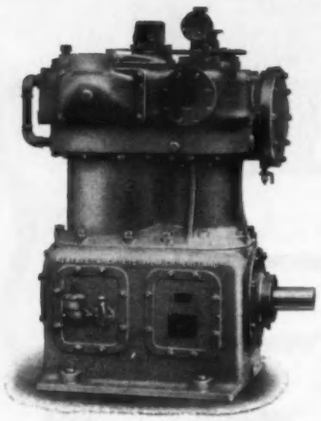

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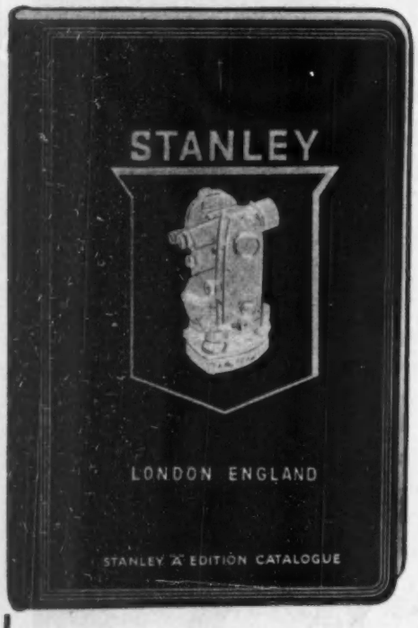

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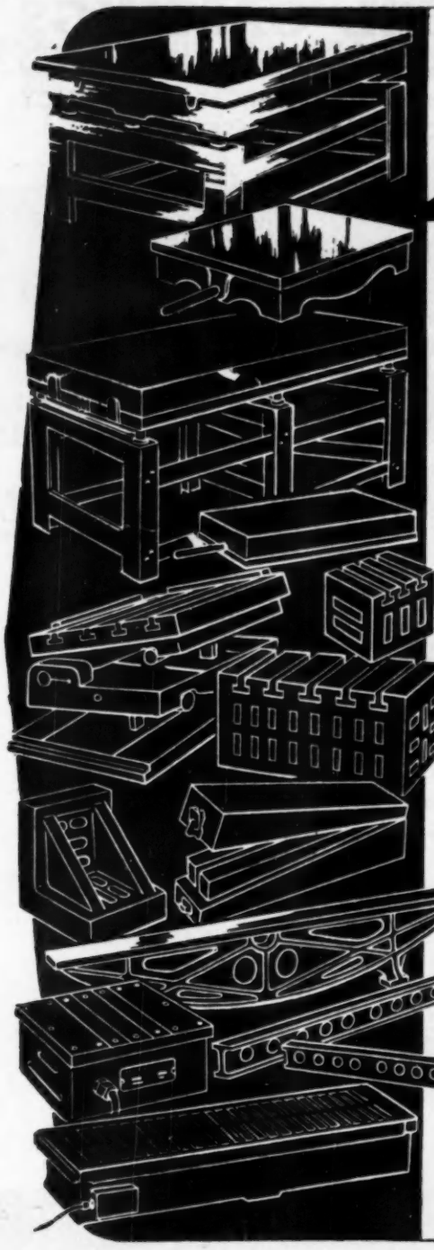

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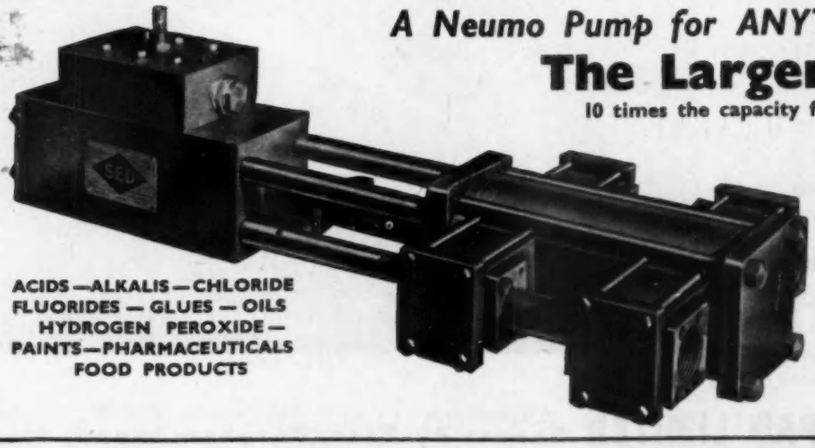

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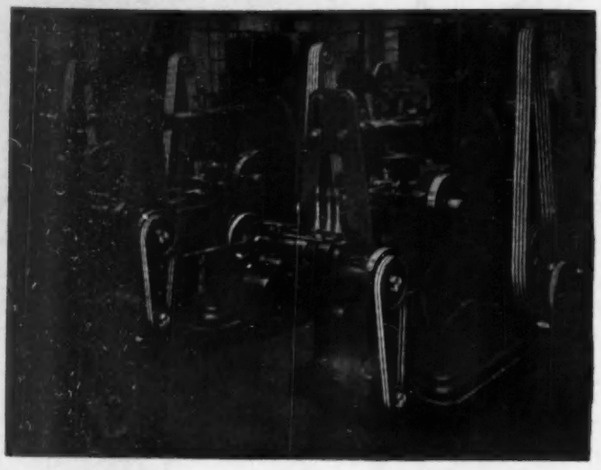

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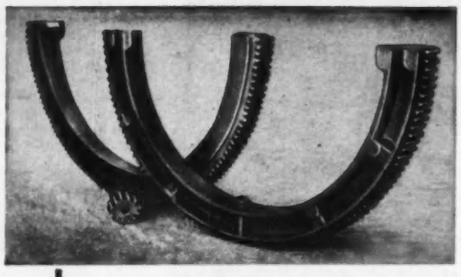

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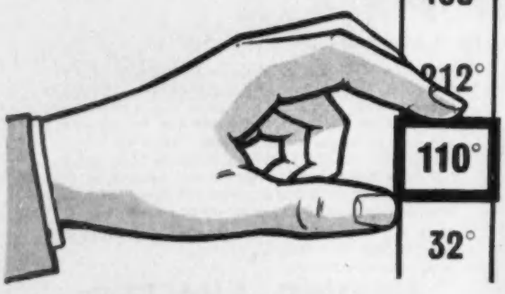

°F	°C
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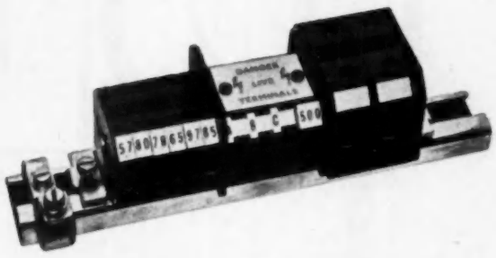

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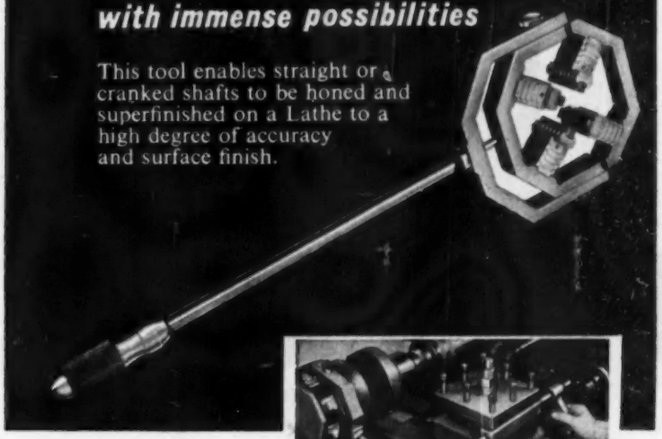

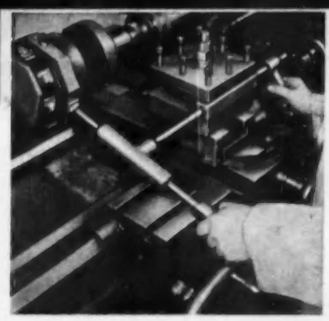

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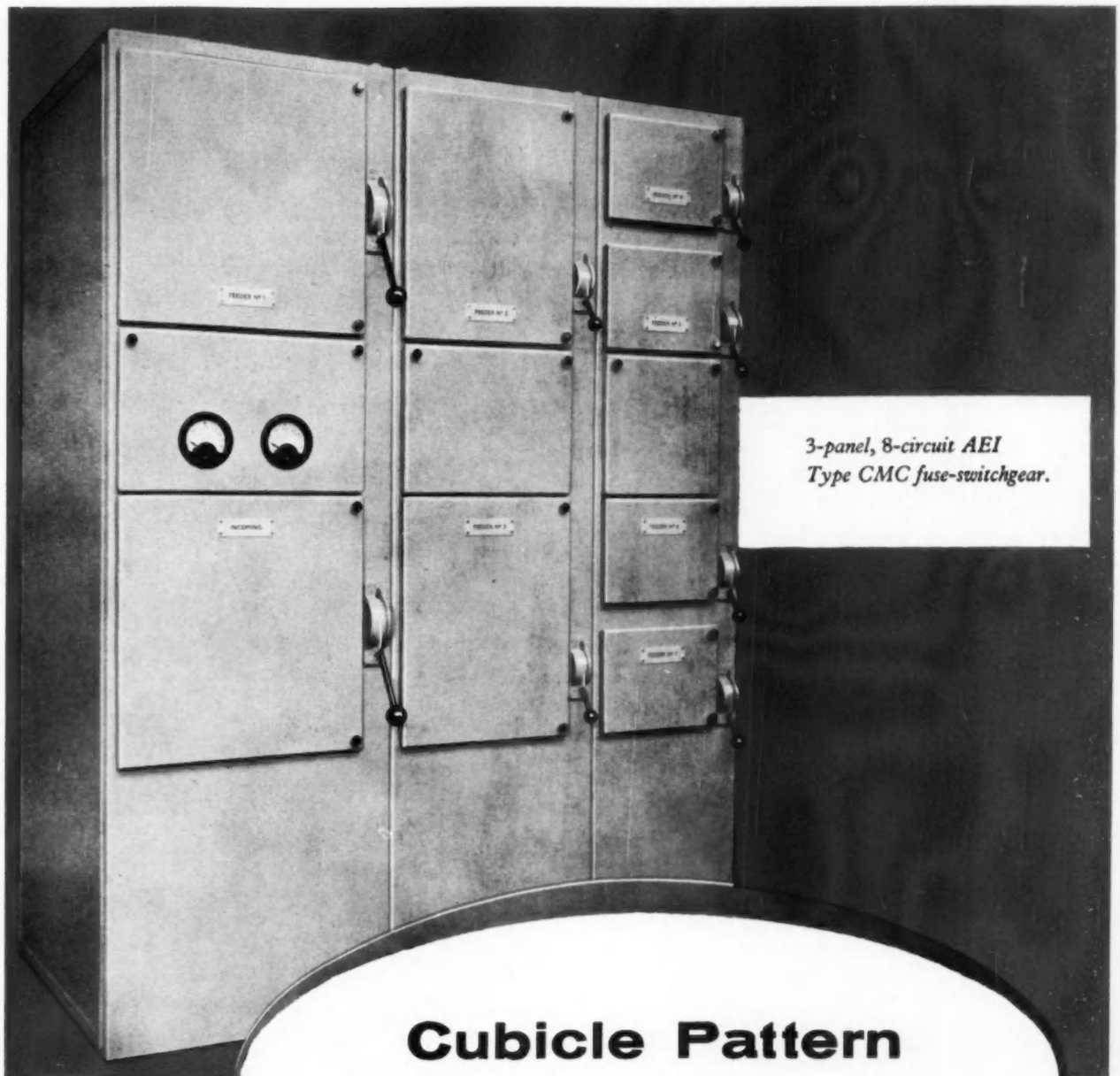

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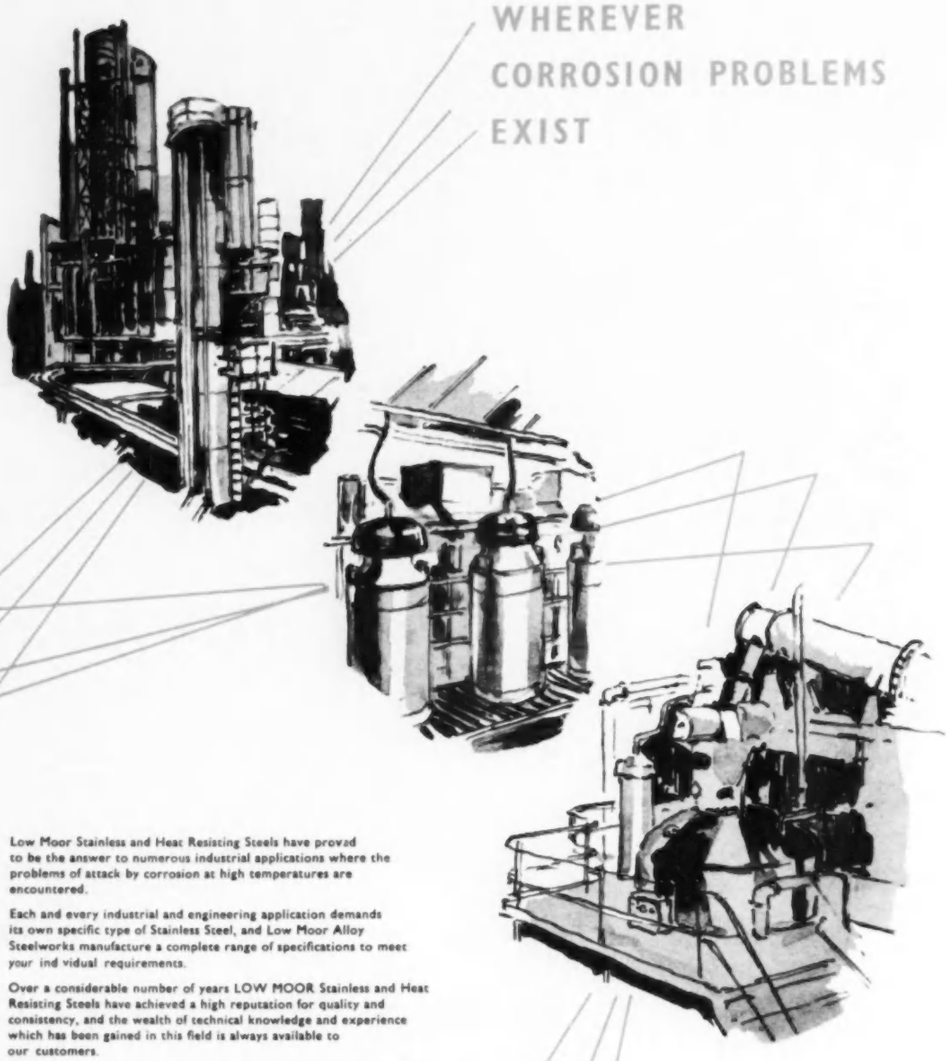

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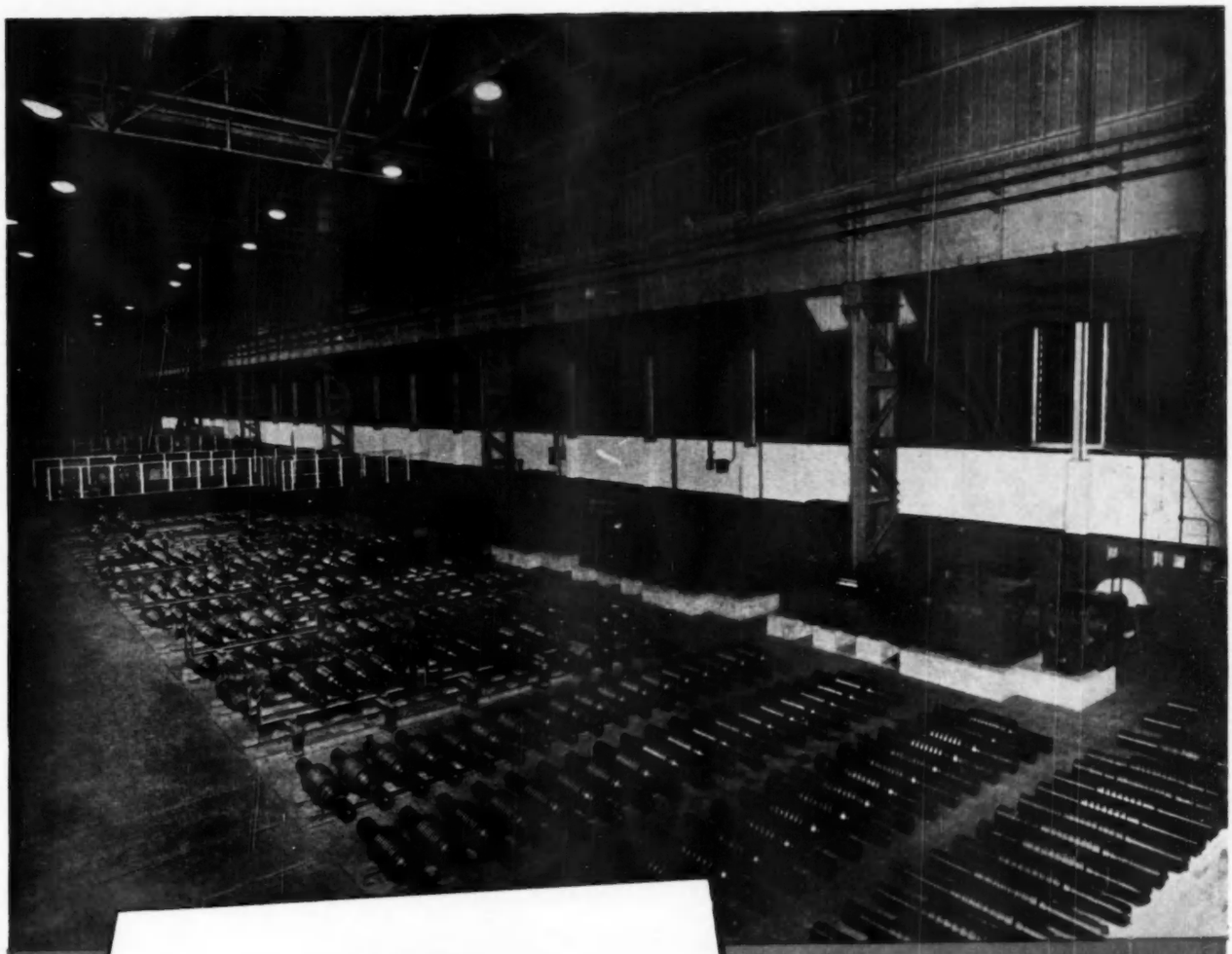

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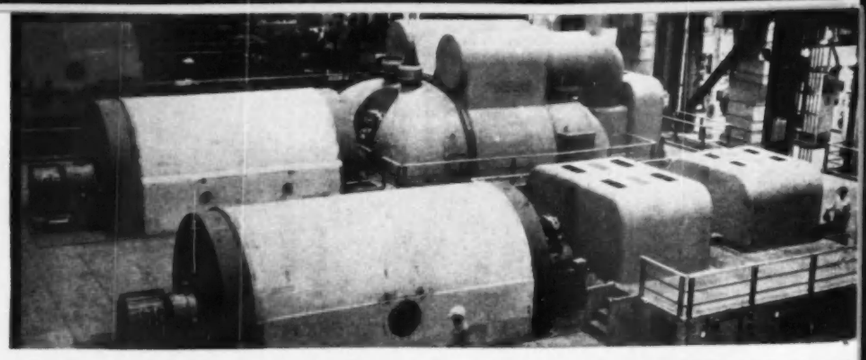

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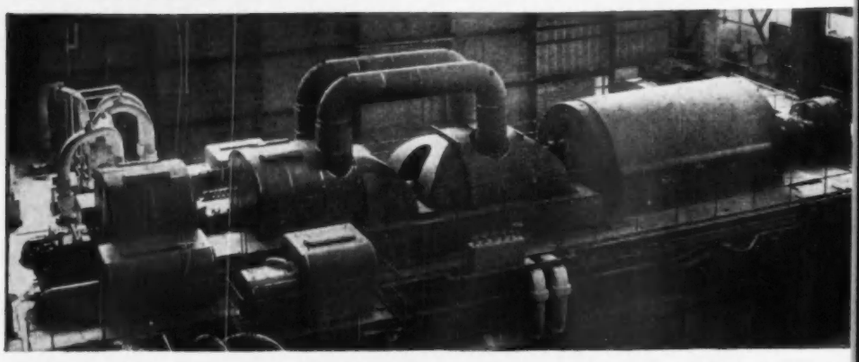
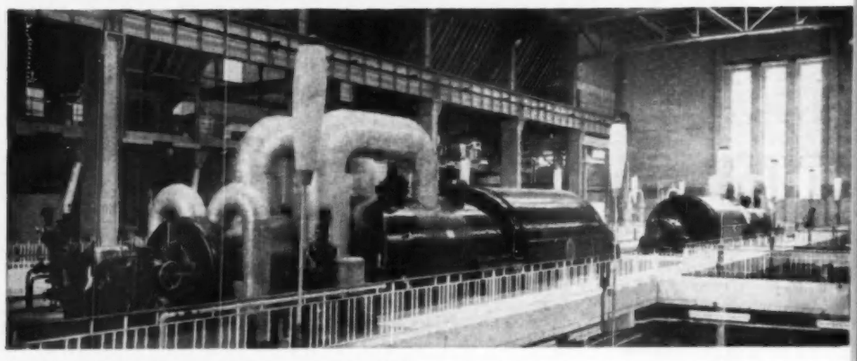
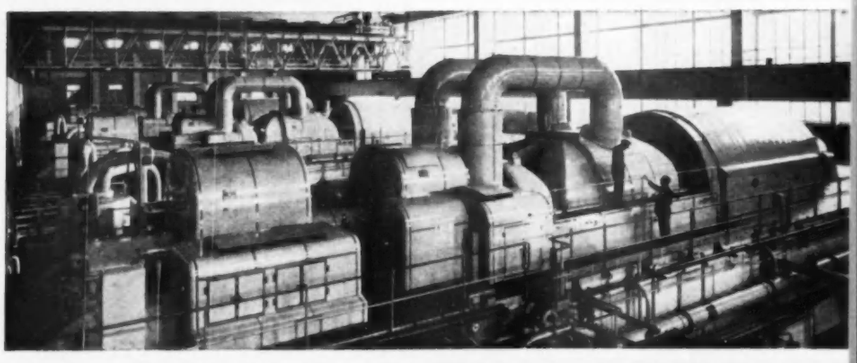


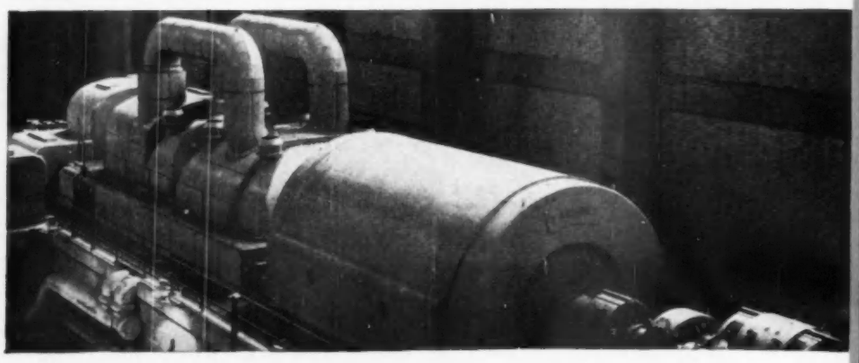
One of three PARSONS 120 MW turbo-generators at Kincardine power station, Scotland



Two PARSONS 60 MW turbo-generators at Little Barford power station, England



Three PARSONS 100 MW turbo-generators at Ferrybridge power station, England



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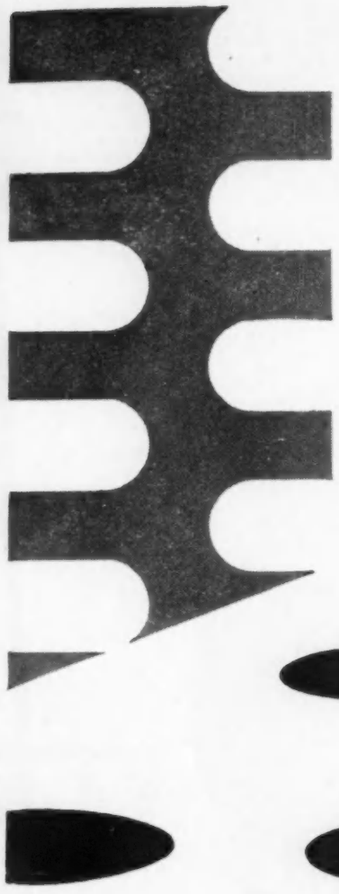

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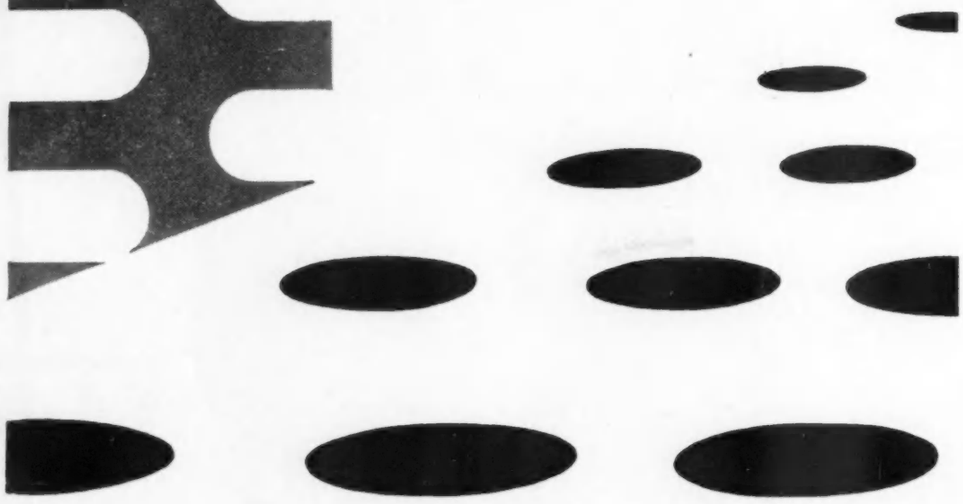

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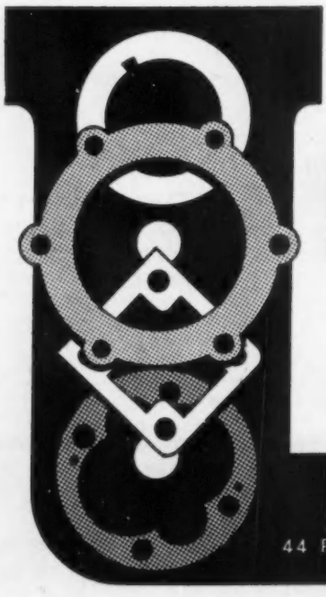

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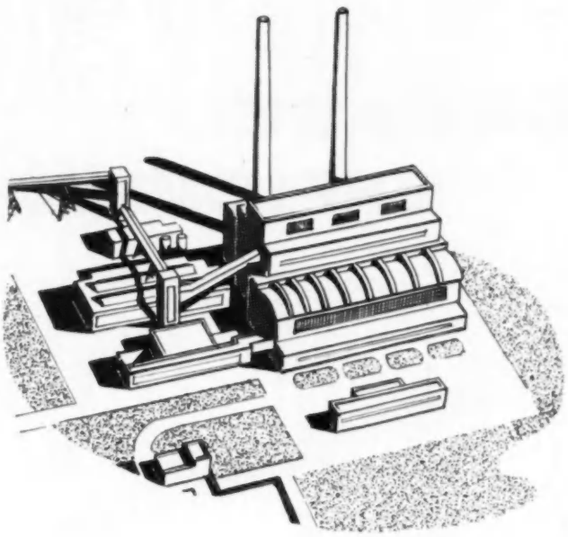

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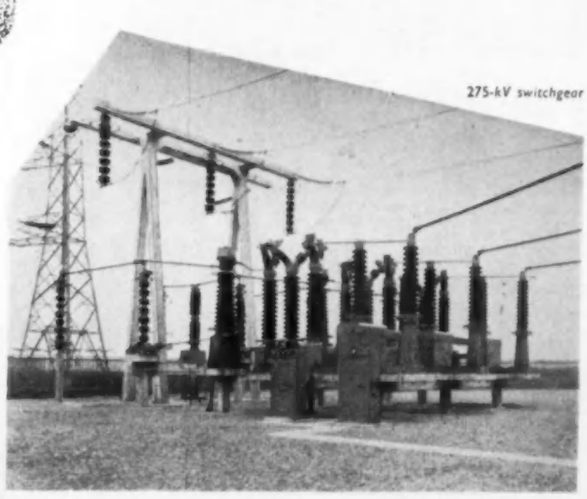
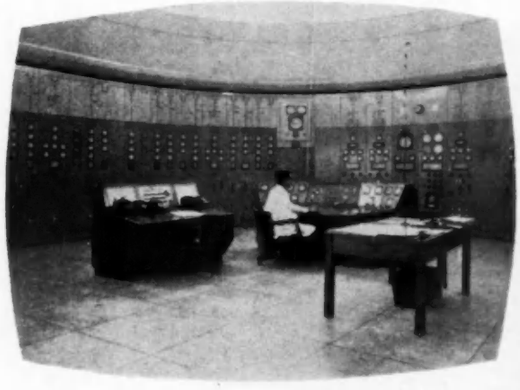
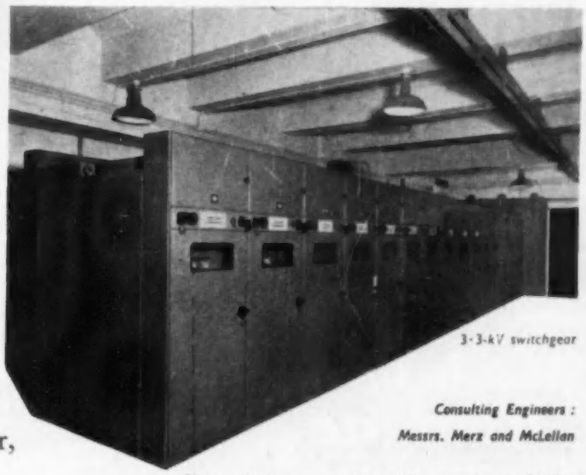


275-kV switchgear



Main control-room



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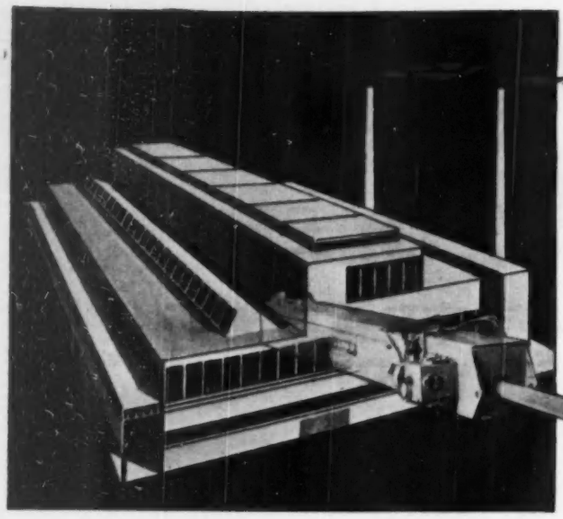

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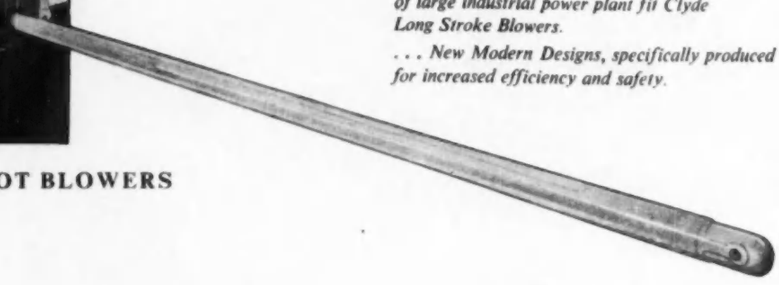

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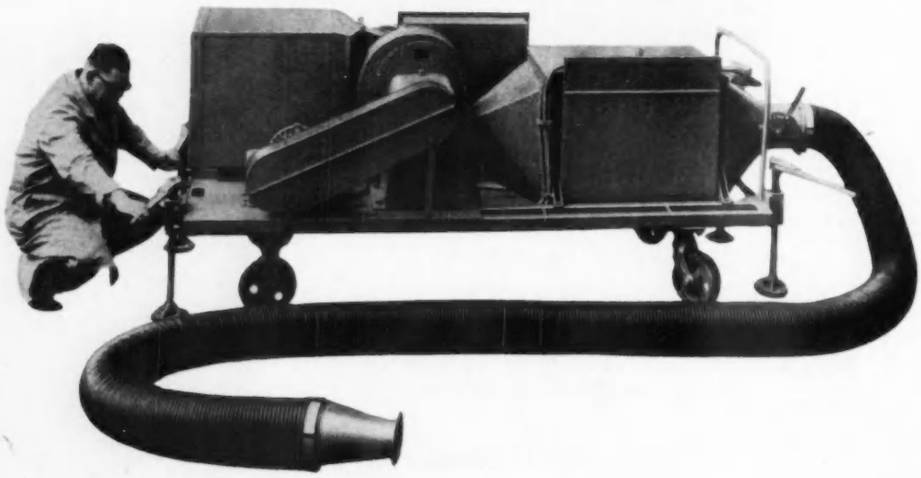

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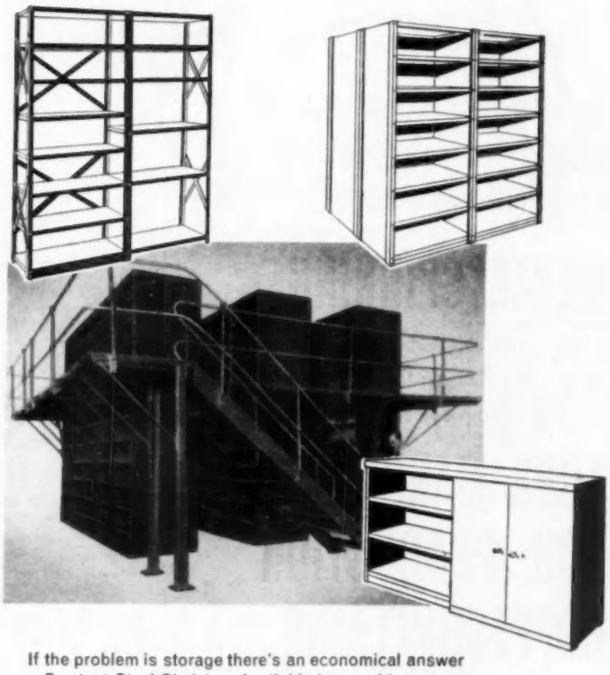

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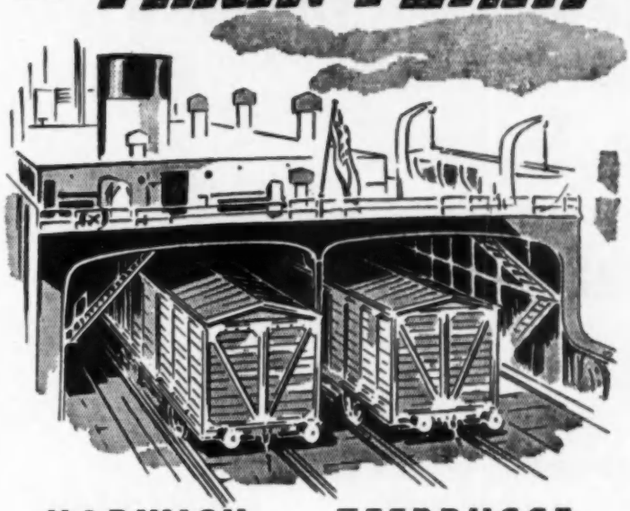

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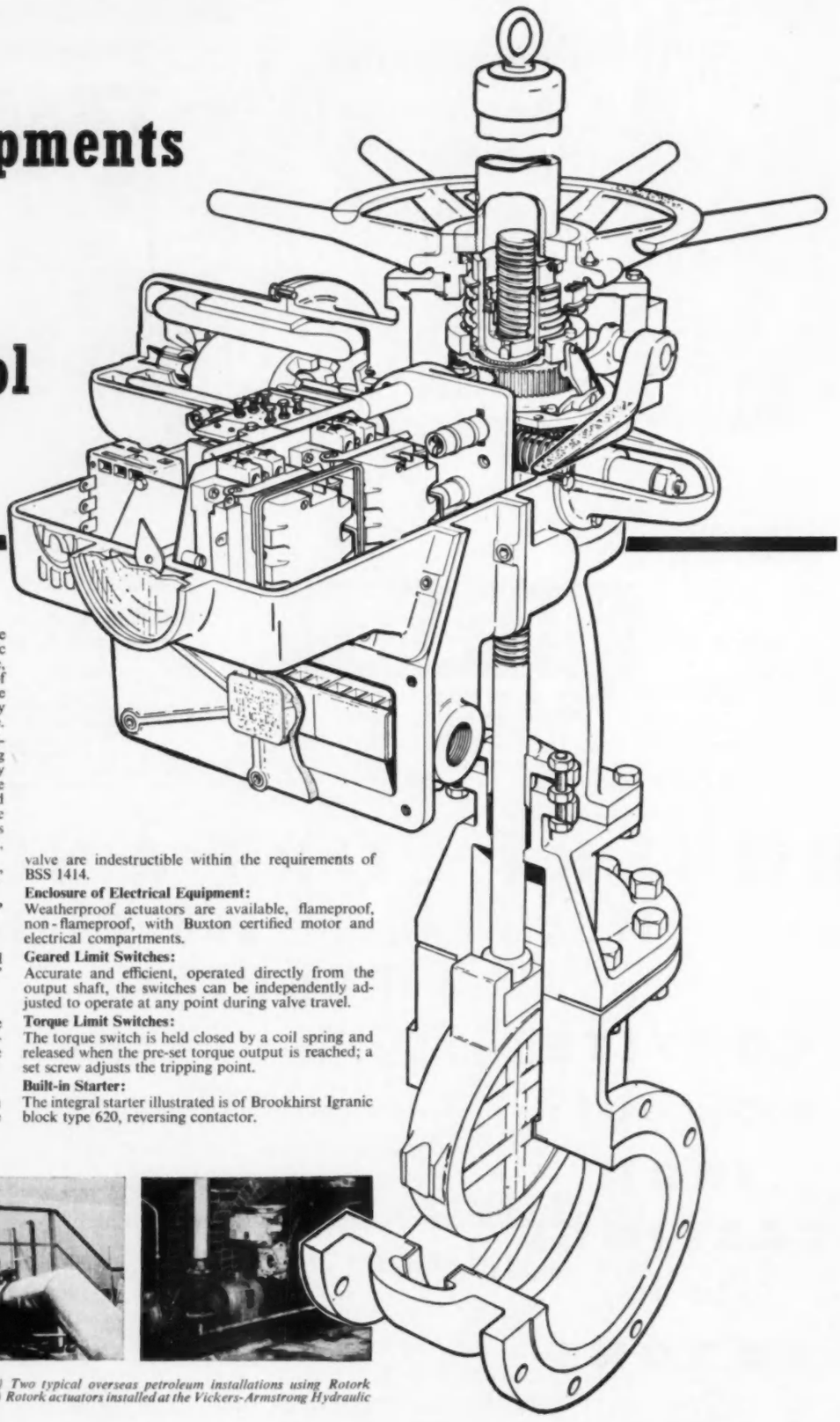

Valve manufacturers and users all over the world have helped Rotork develop their new series of electric actuators — the 'A' range. Such practical advice, coupled with Rotork's comprehensive experience of valve control, ensures that the 'A' range offers the most competent method available for automatically controlling any size or type of valve from any distance.

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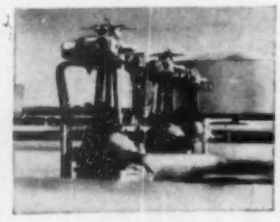

(Left and centre) Two typical overseas petroleum installations using Rotork actuators. (Right) Rotork actuators installed at the Vickers-Armstrong Hydraulic Test Plant.

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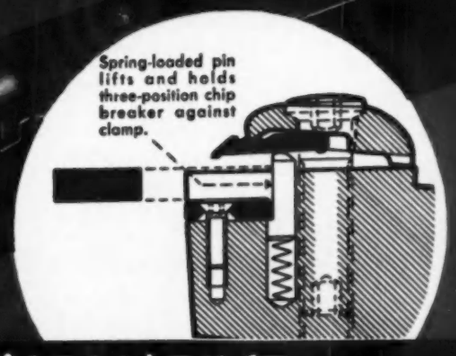

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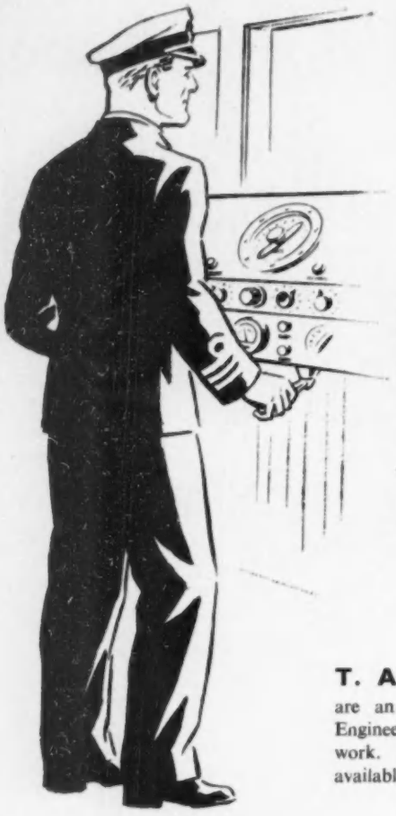

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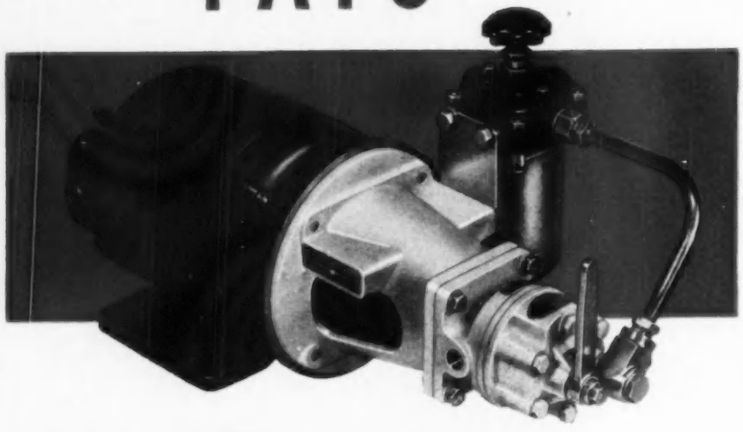

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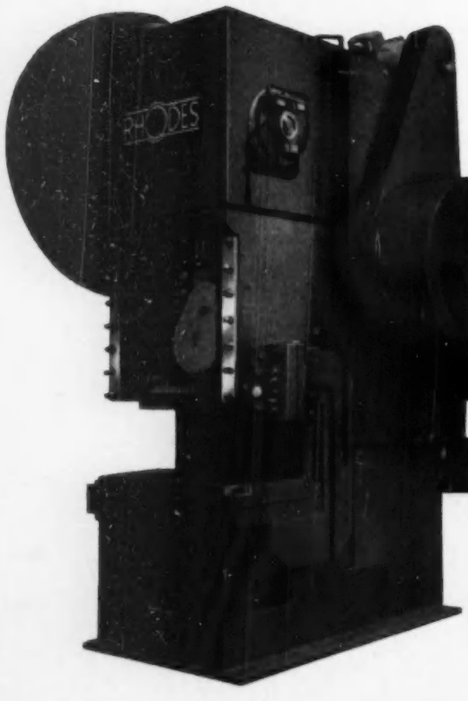

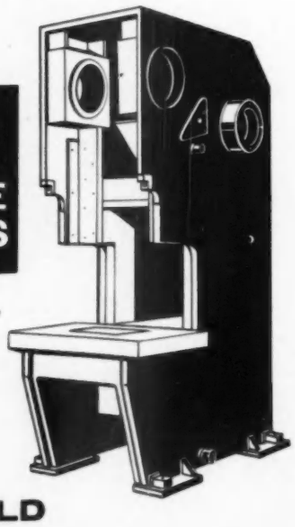

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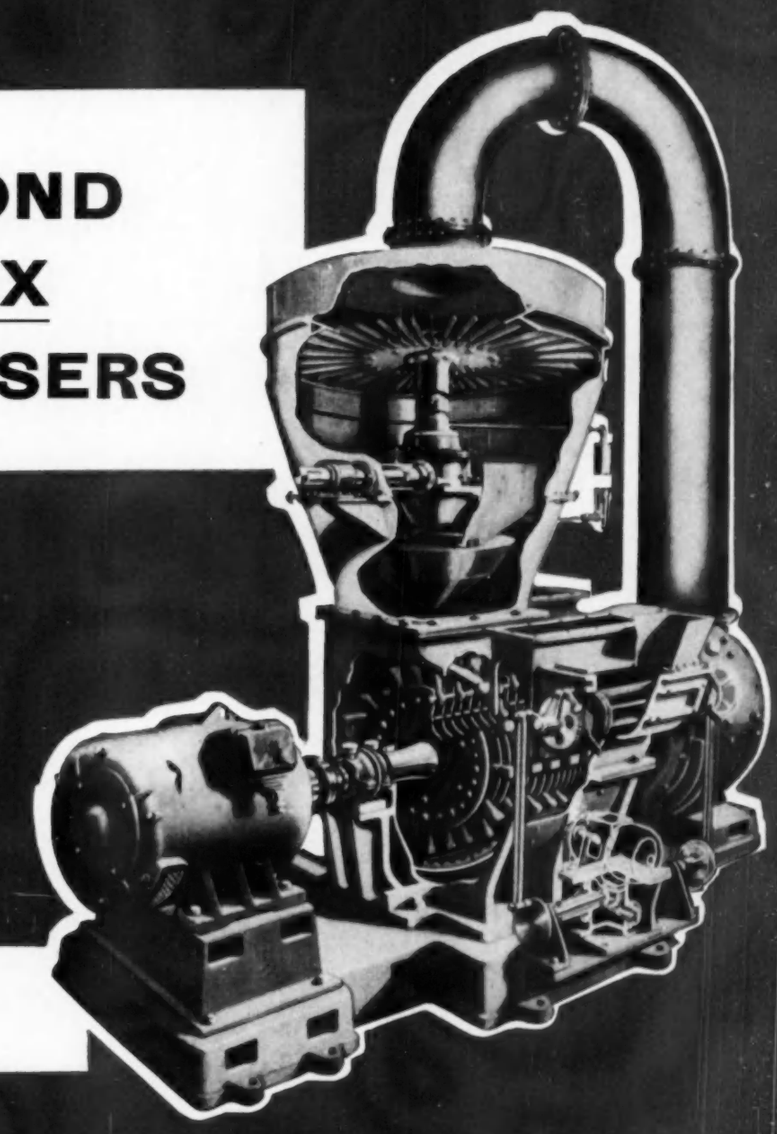

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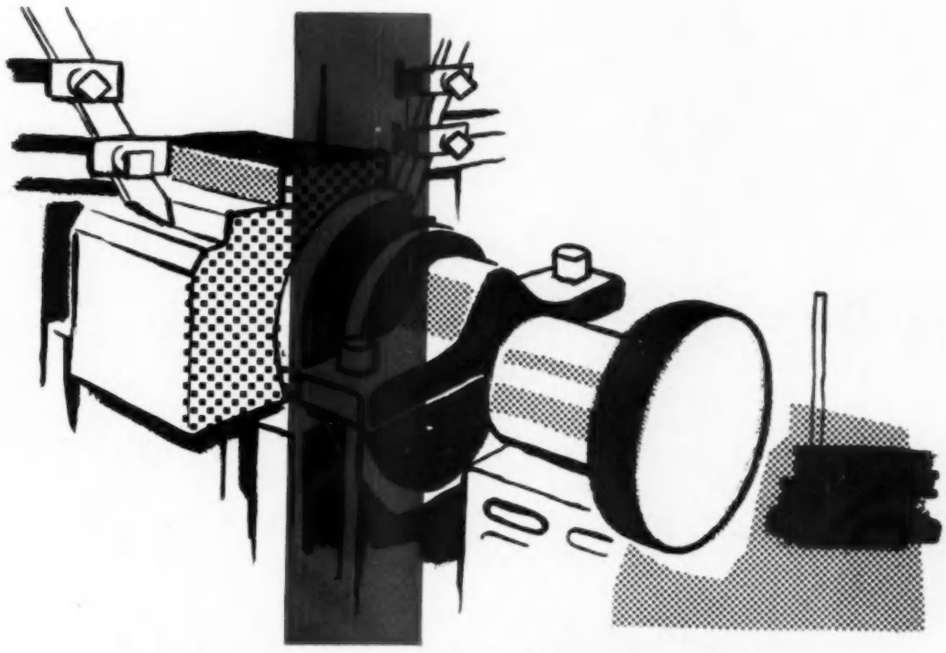

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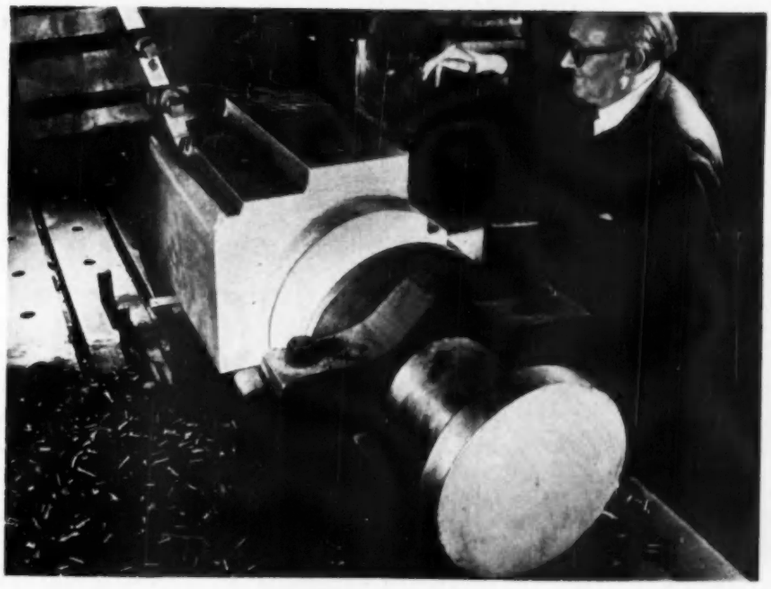

Photograph shows alternator armature shaft being planed.

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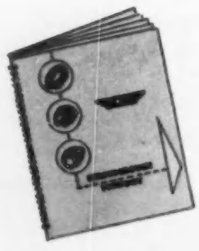

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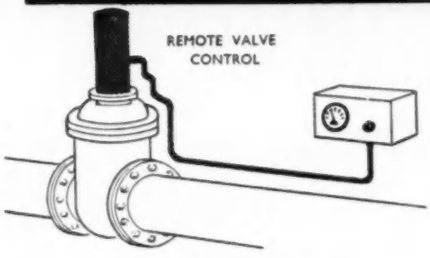

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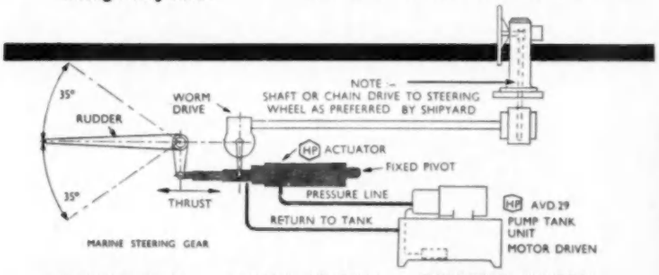

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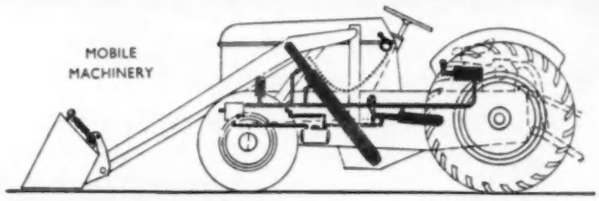

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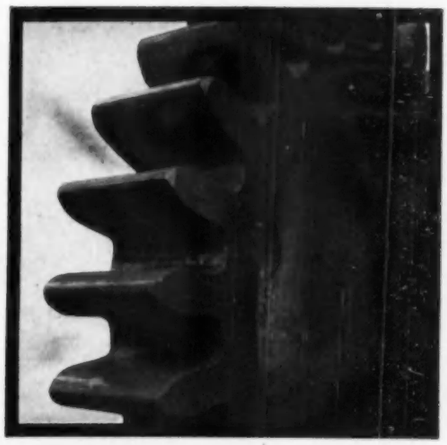

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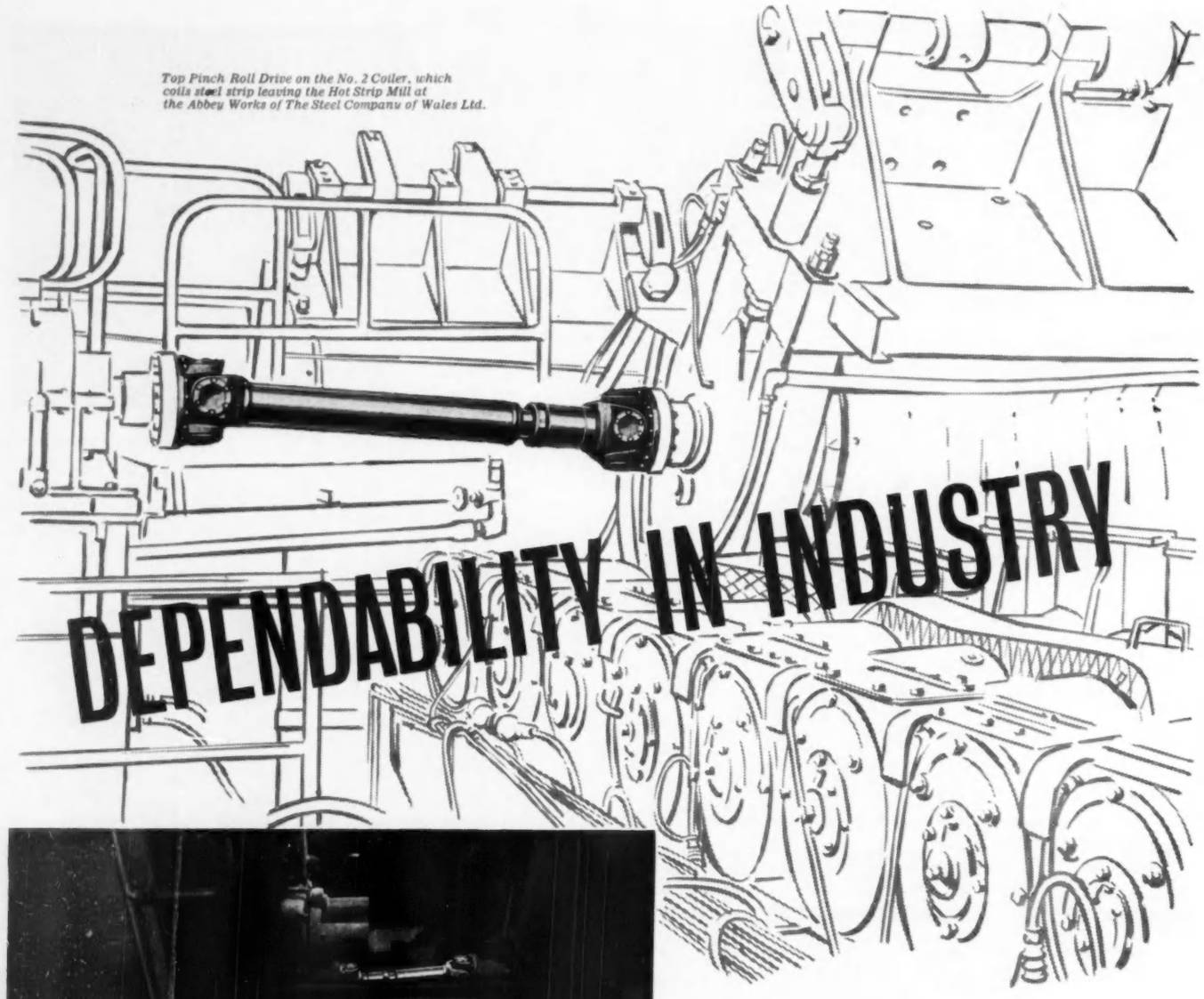
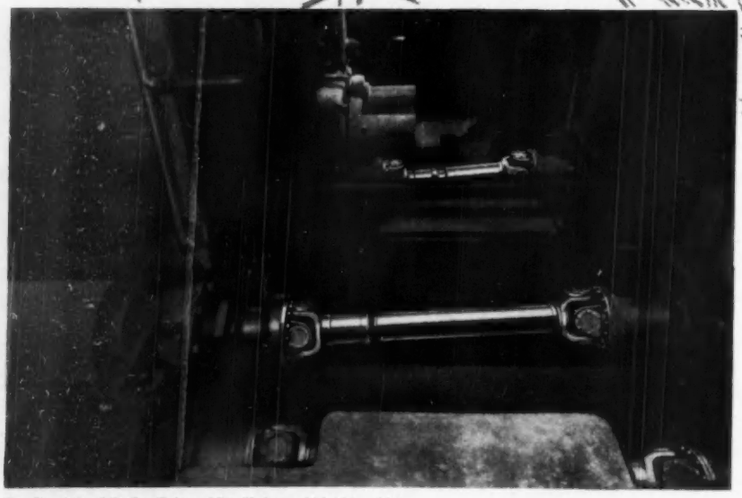


Top Pinch Roll Drive on the No. 2 Coiler, which coils steel strip leaving the Hot Strip Mill at the Abbey Works of The Steel Company of Wales Ltd.

DEPENDABILITY IN INDUSTRY



The No. 2 Feed Roller Drive of the Universal Slabbing Mill at the Abbey Works of The Steel Company of Wales Ltd.

Well known in the Automotive and Railway Industries, Hardy Spicer are now supplying propeller shafts and universal joints in increasing quantities for other engineering applications. Typical of these are the drive shafts and universal joints used at The Steel Company of Wales Ltd.

Hardy Spicer's wide experience ensures the highest standards of design and performance.

Please write for further details and illustrated leaflets.

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PROPELLER SHAFTS

Product of the Birfield Group

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Engineering Division o BIRFIELD INDUSTRIES LIMITED

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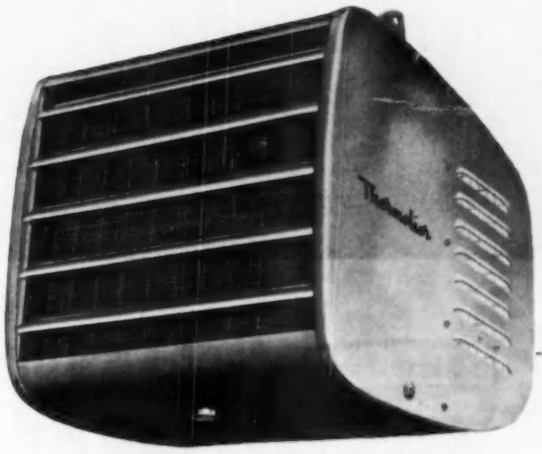
The NEW THERMOLIER unit heater

Registered Design No. 888398



The New Thermolier Unit Heater, employing steam or accelerated hot water, provides heat exactly where and when it is required. Warm air directed to working level maintains a comfortable temperature and constant circulation prevents stagnation. Thermolier Unit Heaters can be installed without sacrifice of floor space and without extensive structural alterations.

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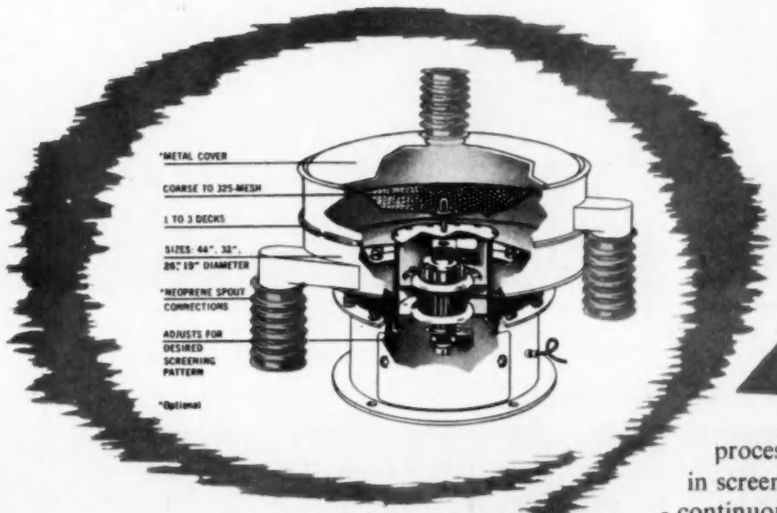

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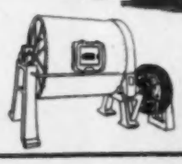
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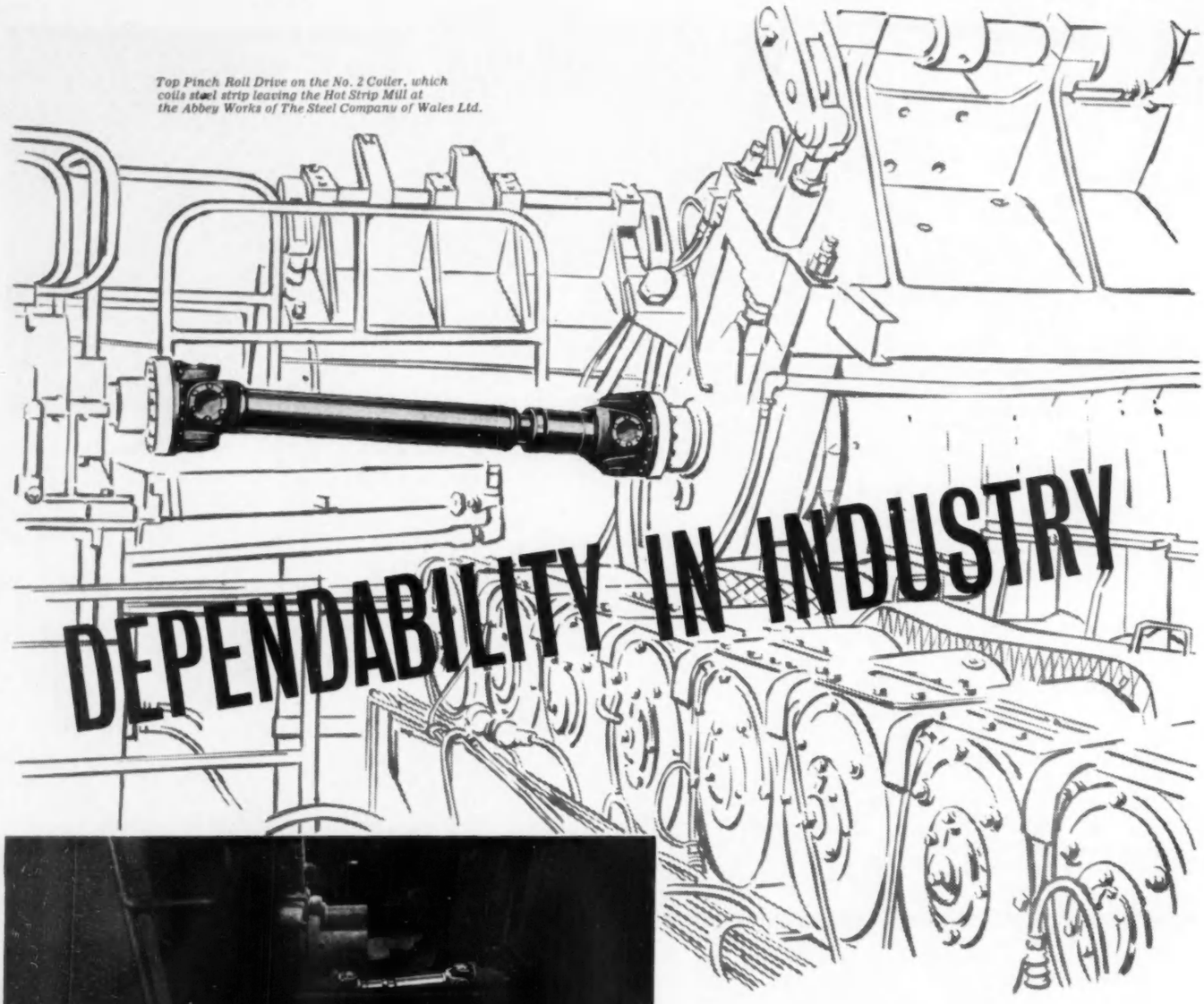

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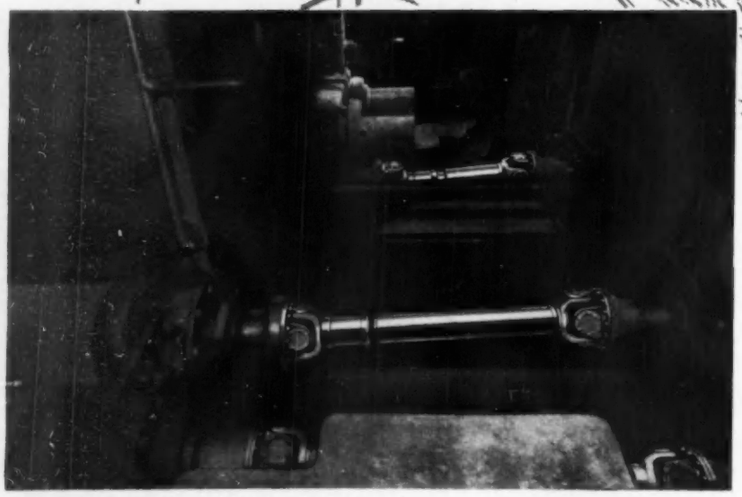

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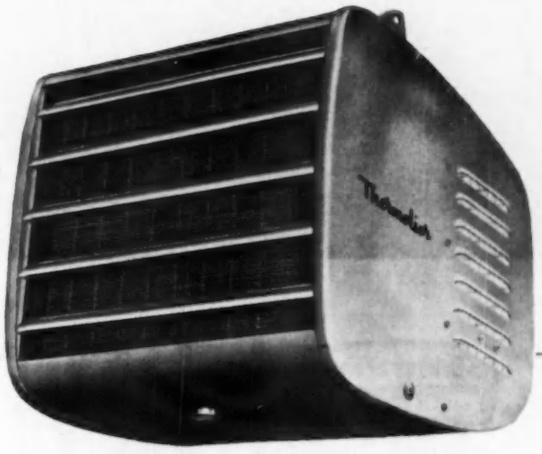
The NEW THERMOLIER unit heater

Registered Design No. 888398



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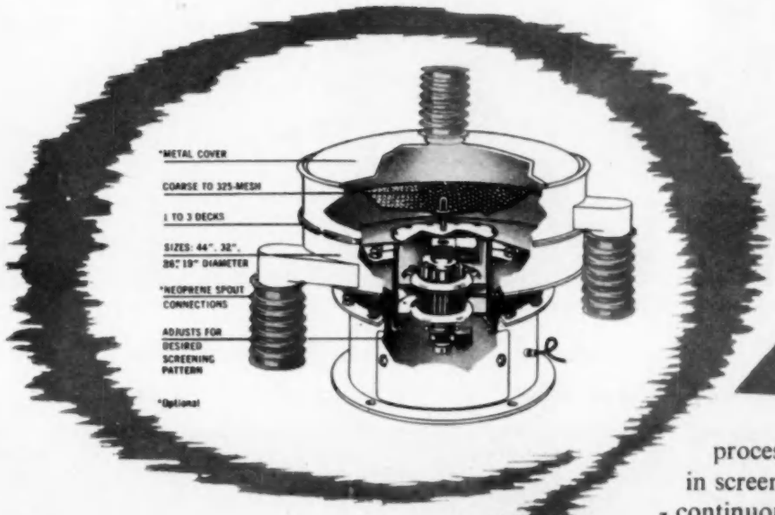

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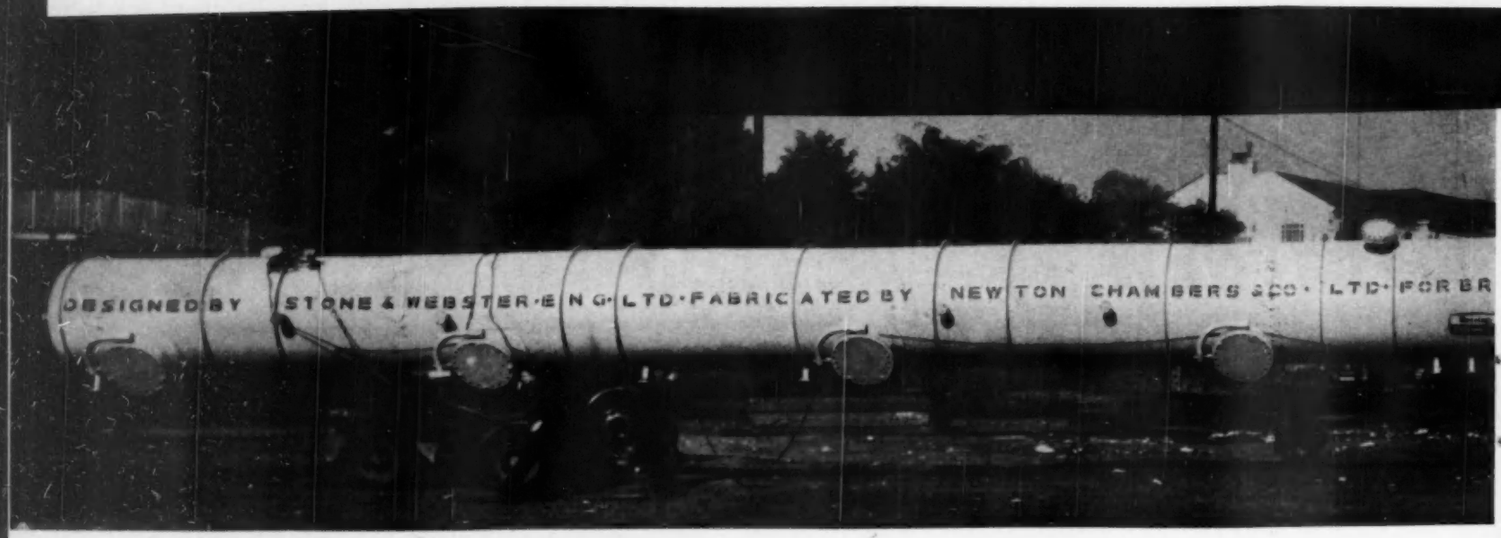

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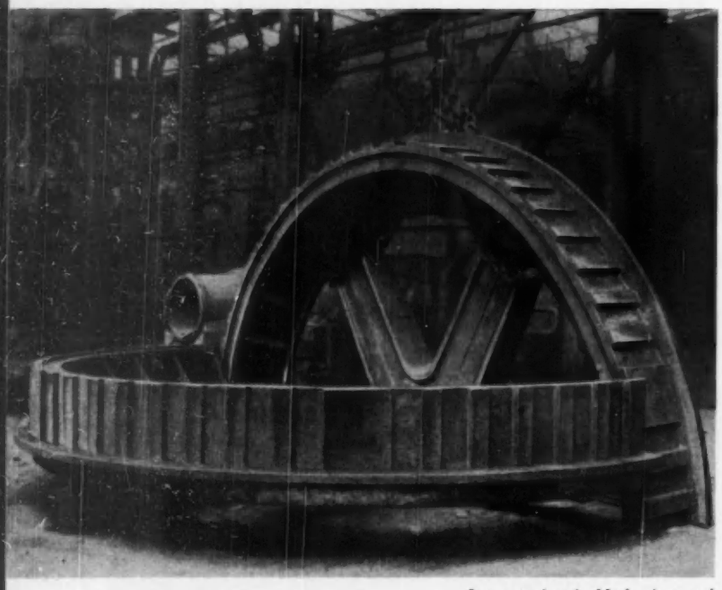
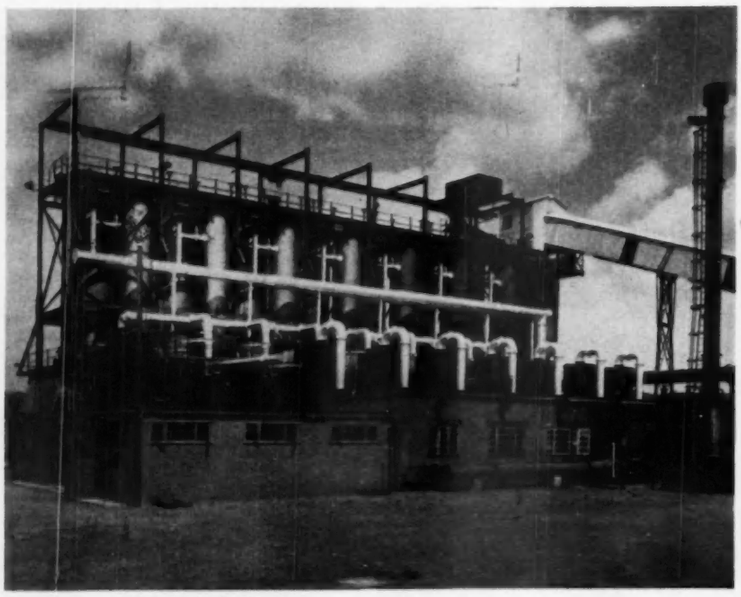


Large castings in Meehanite metal



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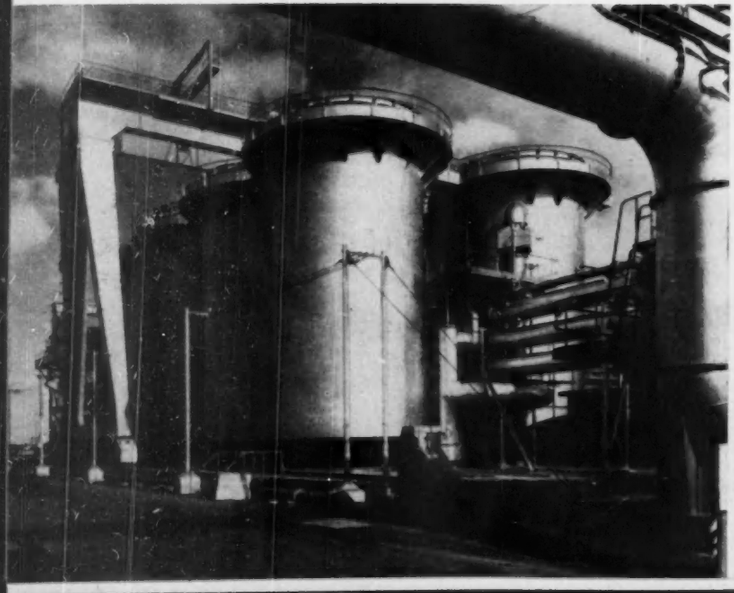
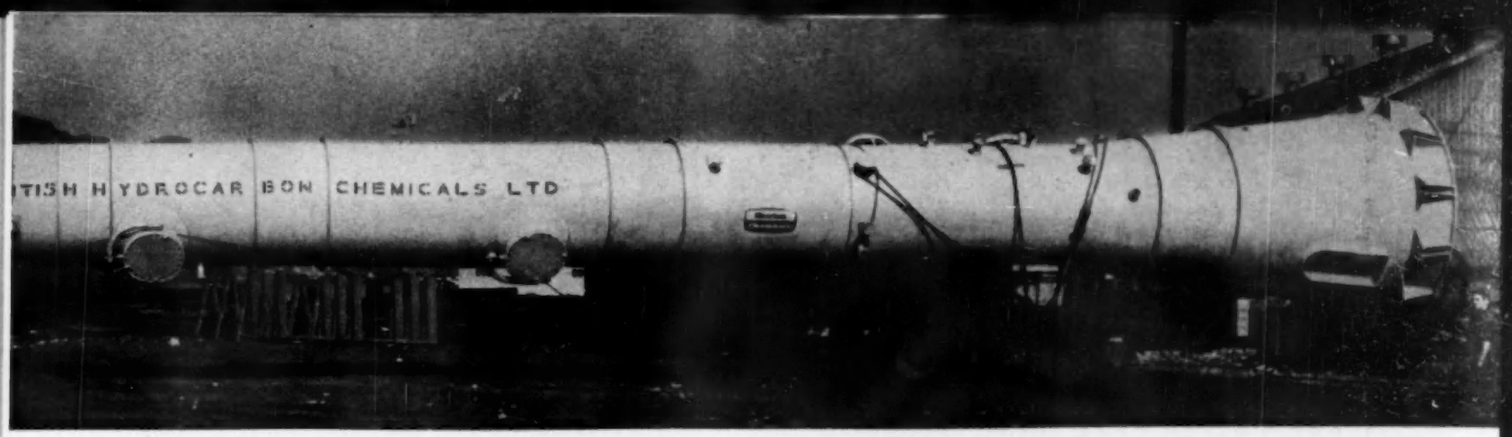


Inka air preheater



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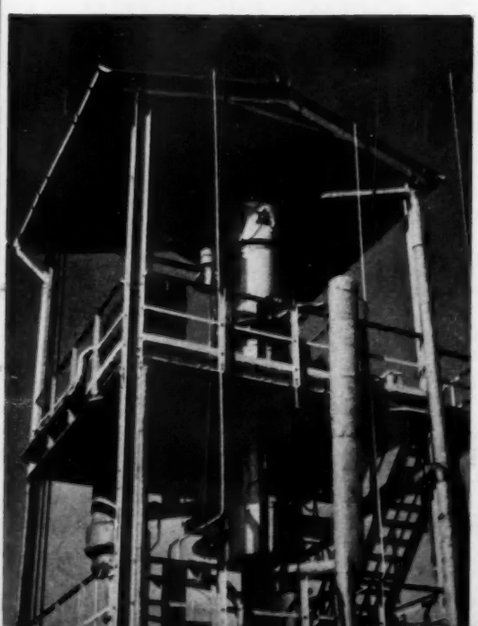
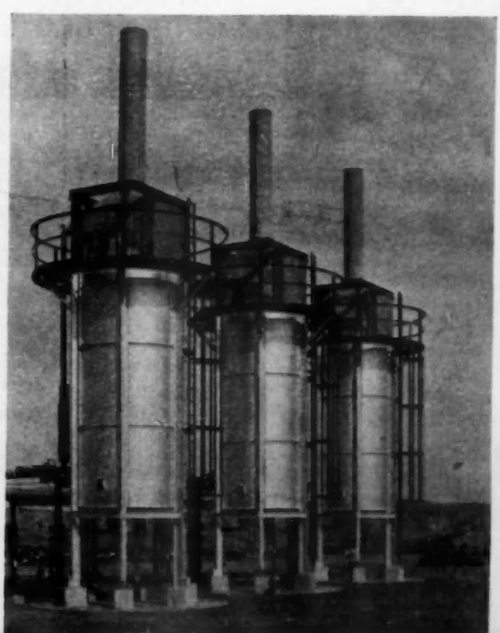
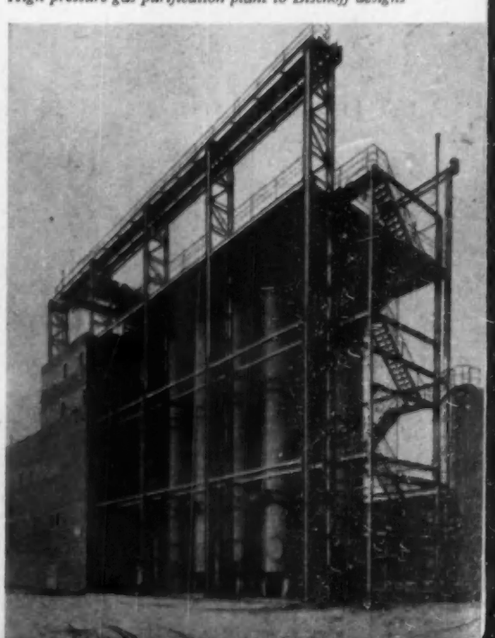


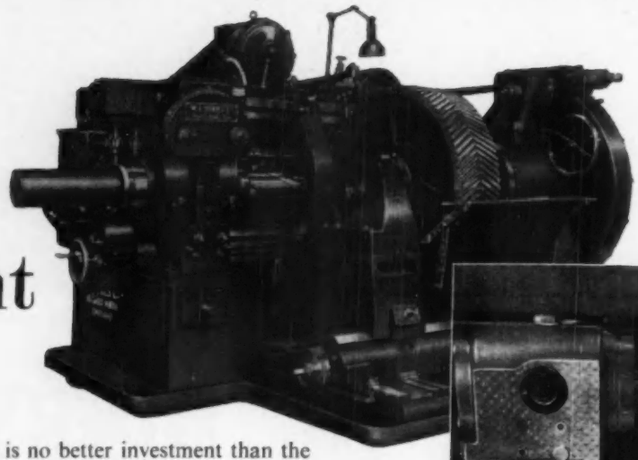
Struthers Wells direct-fired heaters



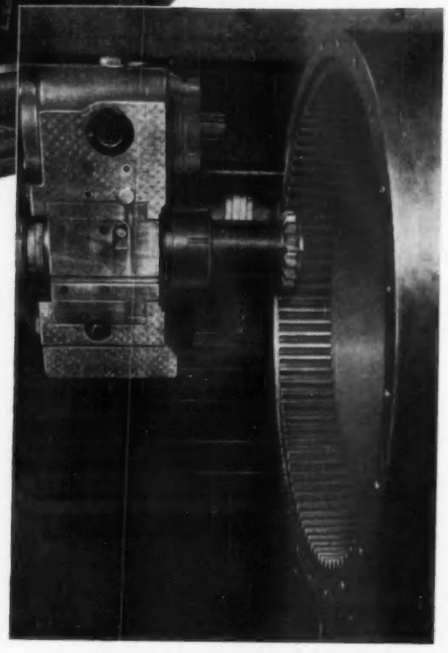
High pressure gas purification plant to Bischoff designs



A sound investment



Capacity 63 in. blank diameter, 16—1½, DP 18 in. face width



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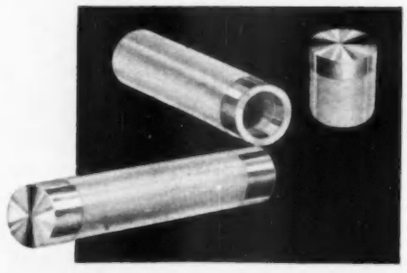

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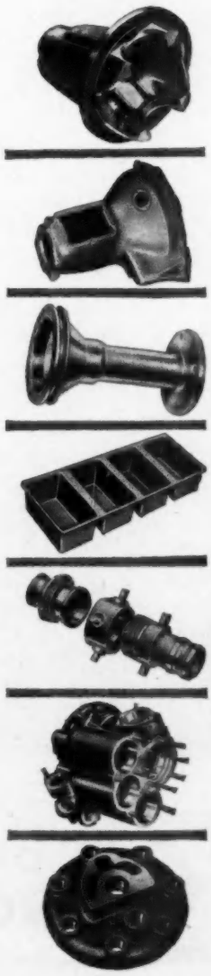

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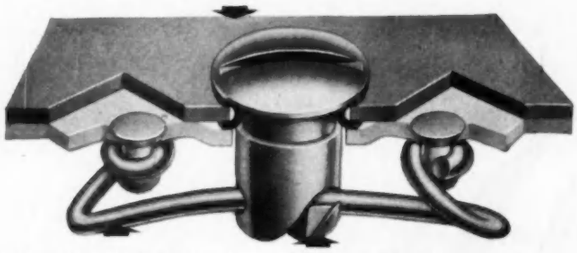

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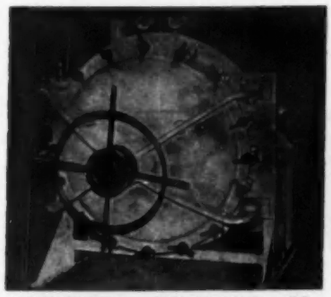

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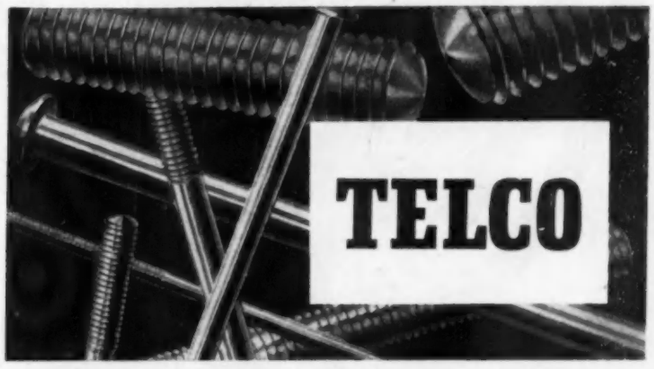

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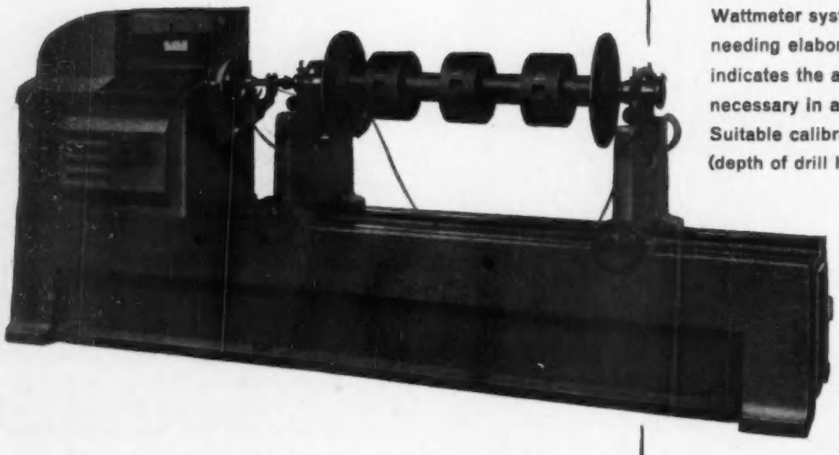

By designing the rotor for balancing, advantage can also be taken of this machine's ability to calculate correction required at pre-selected points.

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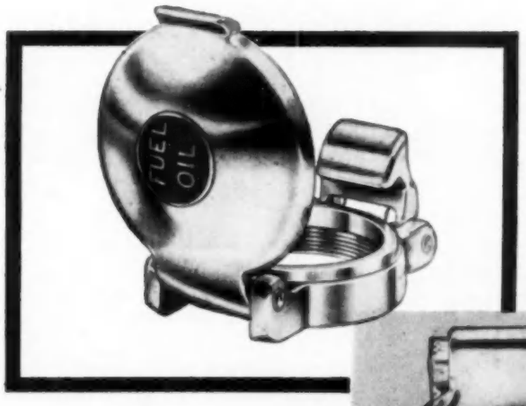

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For use with Hydraulic Fluid Tanks and incorporating a gauze breather plate inside the lid. All flange-mounted caps as illustrated below can be supplied with drop-in gauze filters if required.

An efficient, attractive and robust filler cap can improve the value of your product to your customer. Aston Filler Caps can be found fitted as standard to many commercial vehicles, diesel locomotives and some aircraft. The majority of English and many Continental racing cars also fit them. Illustrated list No. AFC. 1059 will give you further particulars — may we send you a copy ?

BENTON & STONE LIMITED · ASTON BROOK STREET · BIRMINGHAM 6

Telephone: AST 1905 Telex: ENOTS B'HAM 33143

See Enots list of local Stockists on page 35

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The Polish ocean going tug "Jantar" powered by twin National 1575 B.H.P., Regal marine propulsion engines. This vessel is also equipped with National Auxiliary sets.

NATIONAL

Fisheries patrol vessel "Northumbria" powered by a National McLaren 150 SHP Diesel Engine.

Motor Tug "Wooree" powered by a National 1030 SHP Diesel Engine

Trawler "Boston Provost" powered by a National Sovereign 500 SHP Diesel Engine

MARINE PROPULSION DIESEL ENGINES

from 80 to 2400 b.h.p

for powering harbour launches, pilot vessels, fishing boats and trawlers, tugs, ferries and a variety of similar craft within the power requirements of 80 to 2400 b.h.p. in uni-directional form, and from 340 to 1900 b.h.p. as direct reversing engines. In addition to uni-directional engines with reverse reduction gearboxes and direct reversing units, National engines are particularly suitable for diesel electric and multi-engined geared propulsion units. Further particulars on the National Marine Engine range are available on request.

Issued by the Marine Division.

THE NATIONAL GAS AND OIL ENGINE CO. LTD., ASHTON-UNDER-LYNE, LANCASHIRE

Overseas Organisation: HAWKER SIDDELEY BRUSH INTERNATIONAL LTD., National Works, Ashton-under-Lyne, England

A member of the Hawker Siddeley Group

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Photograph by courtesy of North Thames Gas Board

Feeders for Industry

We invite you to send for a copy of our materials handling brochure

Sutcliffe

RICHARD SUTCLIFFE LTD · HORBURY · WAKEFIELD

Britain's Best Conveyors

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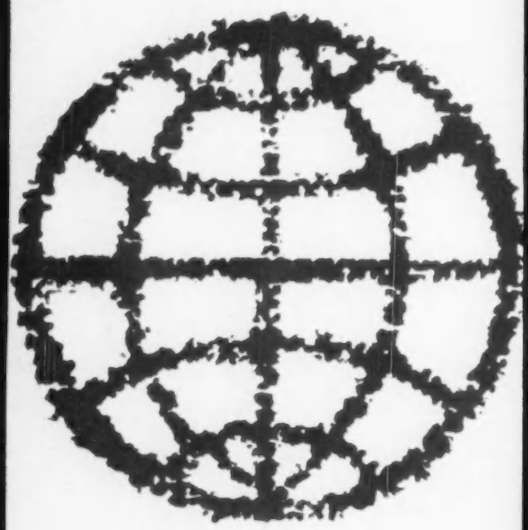

THE WORLD'S BEST DRILL BUSH

THE BUSH WITH NINE LIVES

BRITISH AERO COMPONENTS LTD. WARWICK.

601 Cogent

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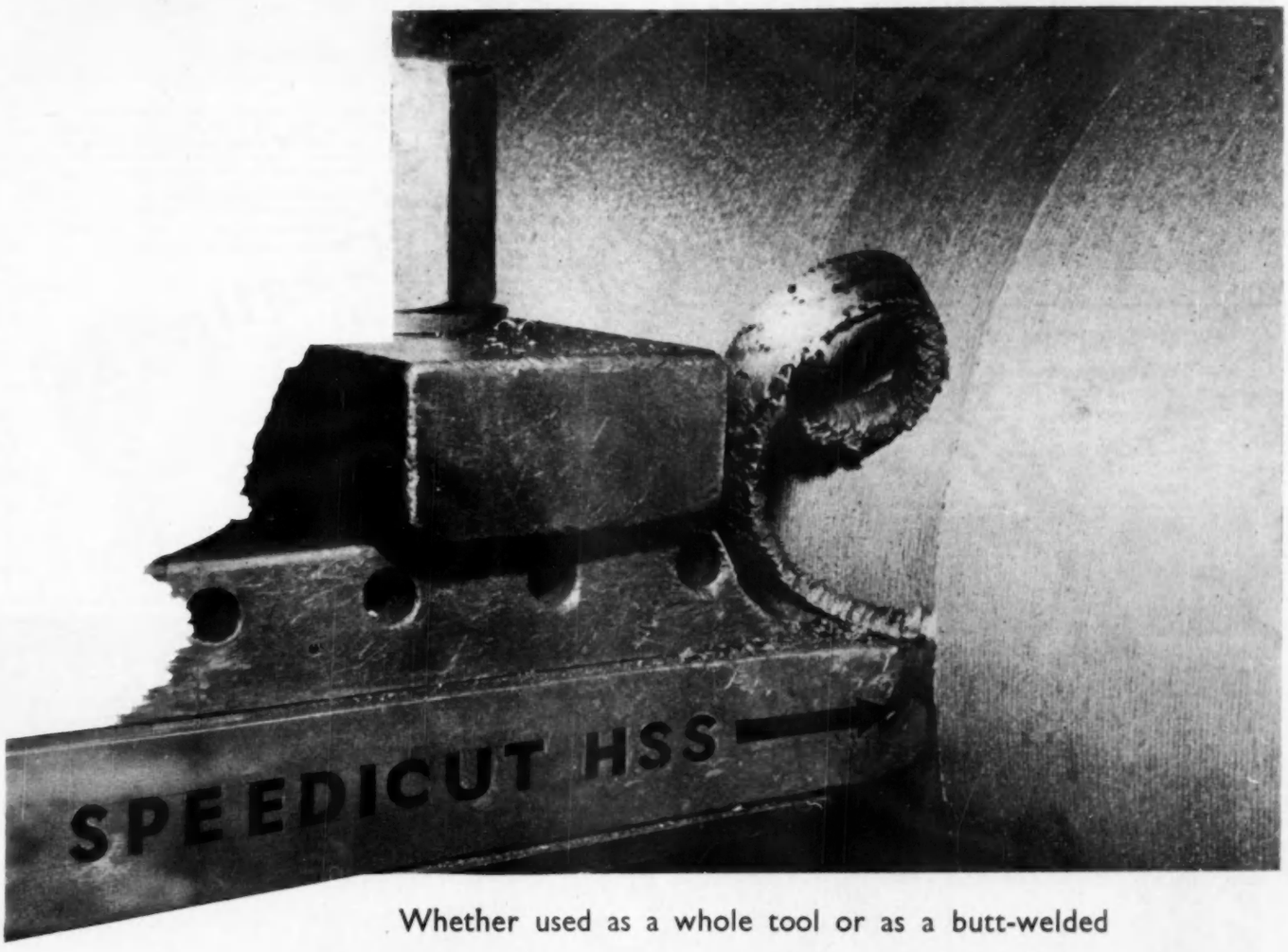
for the toughest tasks



Whether used as a whole tool or as a butt-welded tool or as a brazed-on tipped tool, a Firth Brown Speedicut high speed steel, properly selected for the work in hand, will quickly prove its world-wide popularity for the optimum removal of the toughest metals at the most reasonable tool cost.

by

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS
THOS. FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

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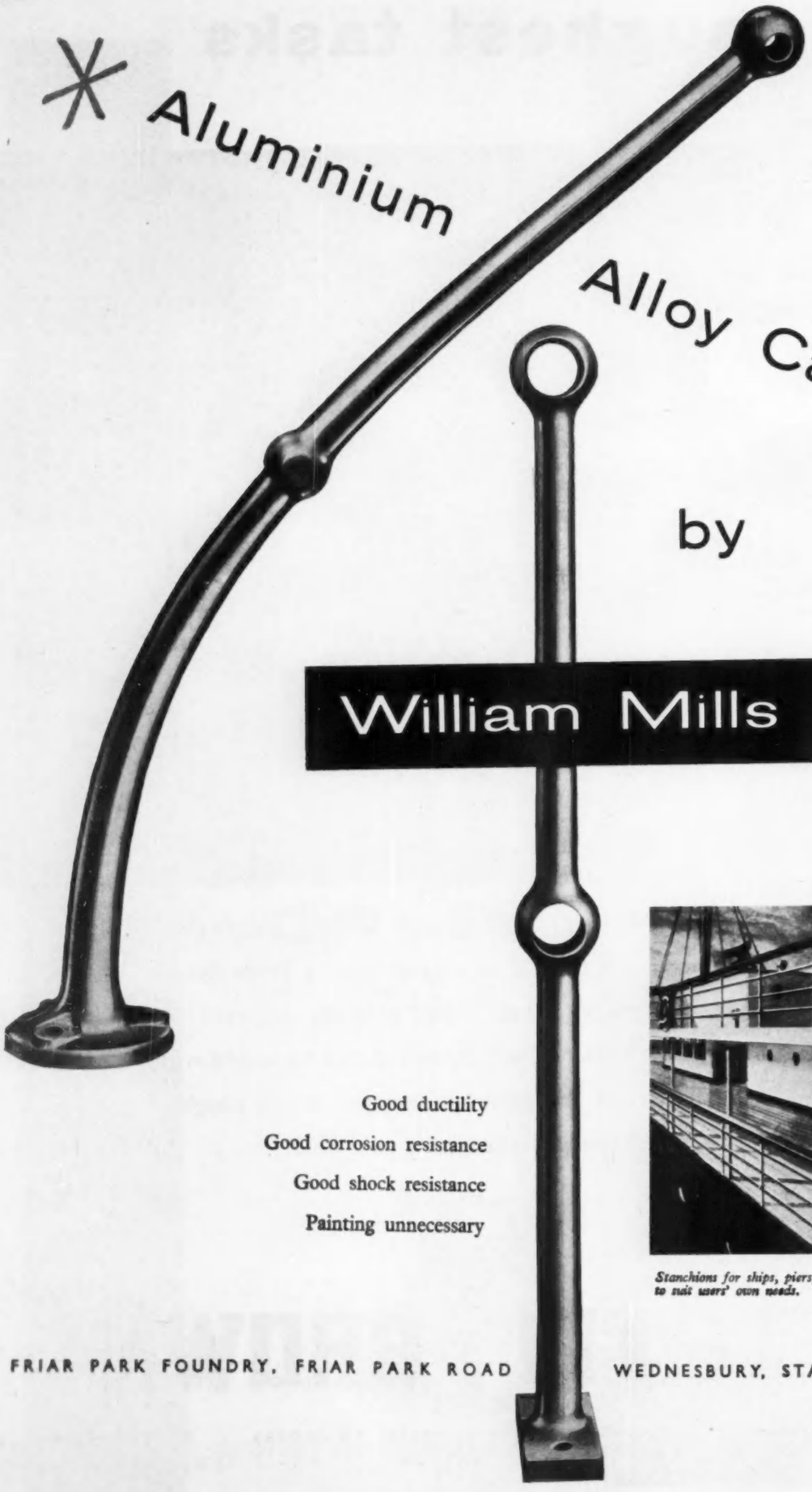
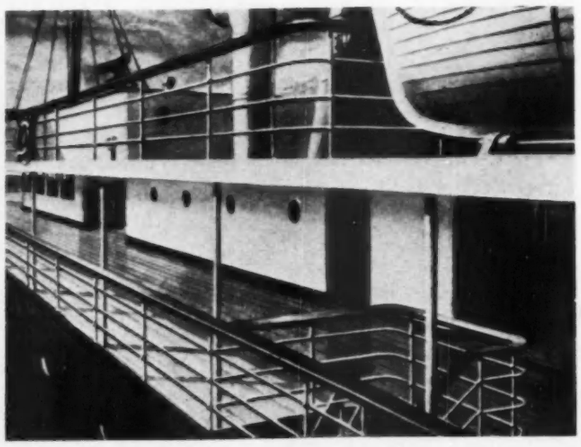
N

* Aluminium Alloy Castings by



William Mills Limited

Good ductility
Good corrosion resistance
Good shock resistance
Painting unnecessary



Stanchions for ships, piers, promenades and industrial uses can be supplied to suit users' own needs.

FRIAR PARK FOUNDRY, FRIAR PARK ROAD WEDNESBURY, STAFFS. Telephone: STOnecross 2276/7

AP125
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CROSS British made products are manufactured by an outstanding process used for the hardening and tempering of steel coils and rings. Covered by many patents, this manufacturing method has enabled components to be made from wire and with superlative accuracy.

Where top standards are essential you can rely on CROSS precision products.

Wire thread inserts · Spring washers · Circlips and retaining rings · Steel piston rings · Jet engine labyrinths.

CROSS
MANUFACTURING CO. (1938) LIMITED
COMBE DOWN · BATH
SOMERSET · *Phone: Combe Down 2355/8*
Grams: 'CIRCLE' Bath

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STANDARD VERTICAL INDUSTRIAL THERMOMETER

to indicate, record or control temperature

Rototherm

THE BRITISH ROTOTHERM CO. LTD.
Morton Abbey, London S.W.19
Phone: Liberty 7061 (6 lines)

BI-METAL MERCURY-IN-STEEL VAPOUR PRESSURE

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INDUSTRIAL WATER TREATMENT

FILTERS
SOFTENERS
Lime-Soda and Base Exchange
BOILER FEED CONDITIONING EQUIPMENT
CHEMICAL PROPORTIONING APPARATUS
(Chemical Pumps, Gravity Solution Dosers, Dry Feeders))

UNITED FILTERS & ENGINEERING LTD
LONDON S.W.15
Phone: PUTney 4461 Grams: Unifilters, Put, London

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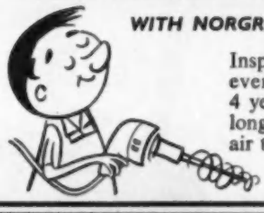
TESTS PROVE

Air Tools operate over 20 TIMES LONGER with *Norgren* MICRO-FOG lubrication

Air operated screw drivers were tested under identical simulated working conditions.

WITHOUT LUBRICATION

Complete failure occurred after an equivalent of only 10 weeks of operation!



WITH NORGREN MICRO-FOG LUBRICATION

Inspection showed only slight wear even after an equivalent of over 4 years of operation — over 20 times longer. This means a big saving in air tool replacement costs.

Norgren MICRO-FOG LUBRICATION

Full details from: C. A. NORGREN LTD., SHIPSTON-ON-STOUR WARWICKSHIRE. *Telephone: 110 & 106*

COMPRESSED AIR NEEDS *Norgren* EQUIPMENT

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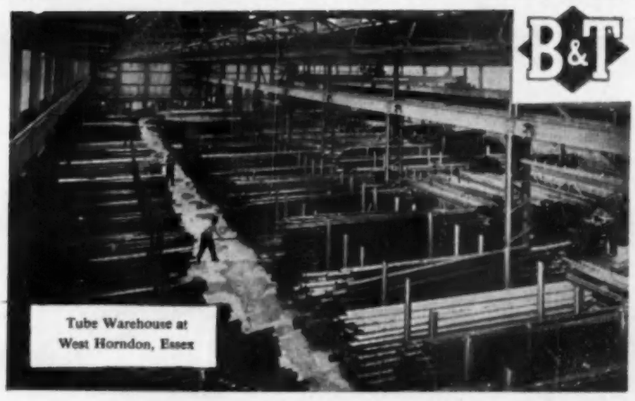

LARGE STOCKS

STEEL TUBES, Gas List Sizes up to 6" n/b.
STEEL TUBES, Non-Standard up to 20" o/d.
HOT FINISHED SEAMLESS STEEL TUBES.
COLD DRAWN SEAMLESS STEEL TUBES.
WROUGHT STEEL FITTINGS.
MALLEABLE IRON FITTINGS.
STEEL BUTT-WELDING FITTINGS.
M.S. FLANGES, Screwed, Slip-on, etc.
BRONZE and CAST IRON VALVES.
POLYTHENE TUBES.

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LONDON
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GLASGOW
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MANCHESTER
Ambrose Street, West Gorton, Manchester 12.

BIRMINGHAM
Stirling Road, Shirley, Birmingham.

Smee's 119/58

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INDUSTRIAL TECALEMIT STOCKISTS

LUBRICATING HAND GUNS
for maximum efficiency and easy operation

REGIONAL DISTRIBUTORS

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P.O. Box 104
393-401 Parliamentary Road, Glasgow, C.4
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SMITH & GRACE (SALES) LTD
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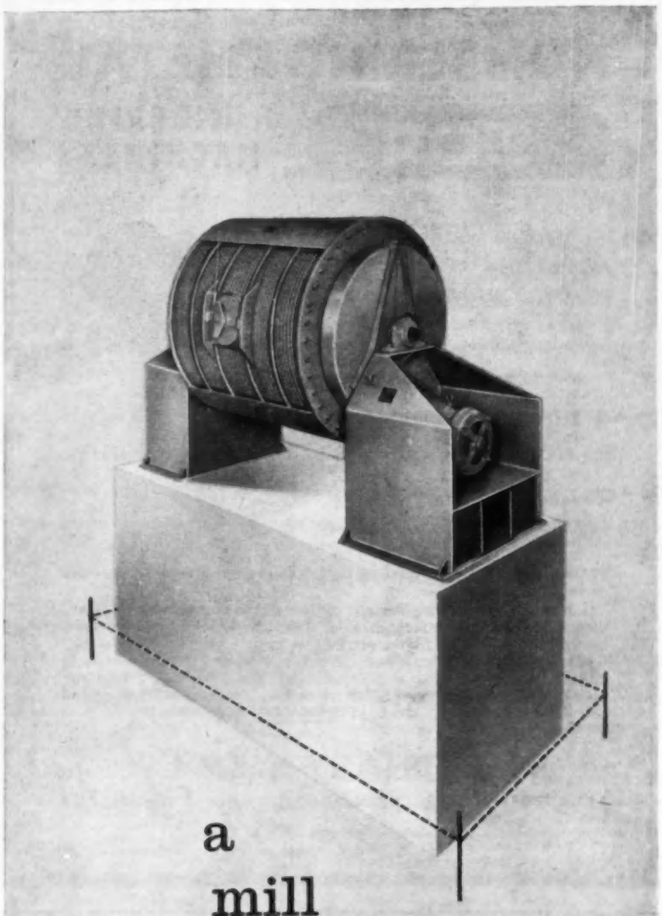
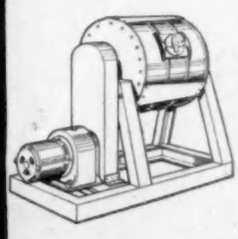


a mill in a million

A Linatex Ball Mill has many times the life of the conventional type. It's the only mill with a cylinder of compressed Linatex reinforced with tie rods. It grinds faster, finer, quieter. The milled contents of the drum can't be contaminated. No metal is exposed internally.

All 6 types of Ball Mill in this range have wear-defying drums of solid Linatex rubber.

Here's a mill in a million, a low-cost capital investment. Six types available. Why not ask our Resident Engineer in your area for details, or send for free copy of the Linatex Ball Mill brochure?



THE LINATEX ORGANISATION

A world wide service to Industry

WILKINSON RUBBER LINATEX LTD., CAMBERLEY SURREY
Tel: Camberley 1595. Factories and Distributors throughout the world.

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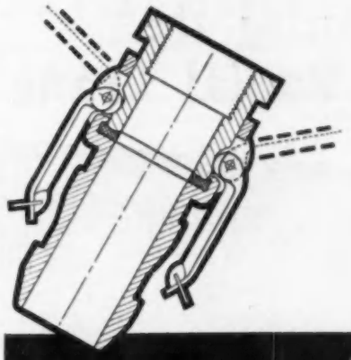
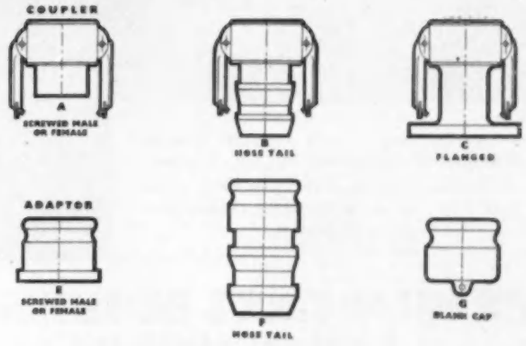


KWIK JOINT COUPLINGS

Section through a typical Kwik Joint coupling. Showing lever in locked position.

An instantaneous coupling for use with water, oil, petrol, steam, gas, compressed air and chemicals. Manufactured in gun-metal, cast iron, aluminium and stainless steel. Working pressures up to 250 psi.

Please write for leaflet.



COMMERCIAL STREET WORKS — ALLEN AH HARRISON — KNOTT MILL MANCHESTER 15

Telephone: CEN 6753/4 Grams: Bronze Manchester

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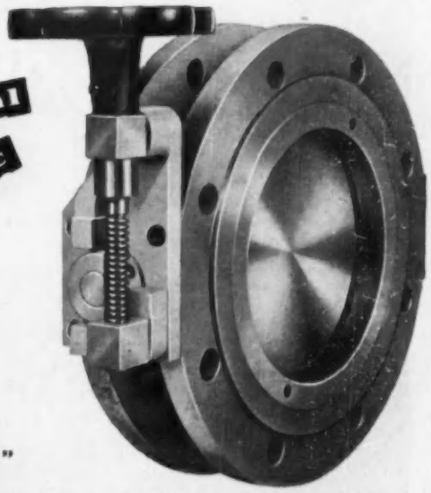
"FLEXISEAT" valves

Pat. No. 753860

positive seal

pivoted disc



Suitable for Water, Oil, Paraffin, Air, etc., up to 150 P.S.I.
Weight approx. ¼ that of usual type of valve.

Standard "FLEXISEAT" Valves are supplied for test pressures up to 300 P.S.I. 3in., 4in. and 6in. sizes available from stock.

"Specials" up to 60in. bore can be made to customers' requirements in terms of pressure, temperature and material specification, etc.

Illustrated literature on request from the manufacturers.

DAVID F. WISEMAN & SONS LTD.
66 CASTLEFORD ROAD, BIRMINGHAM 11.
Telephone: VICtoria 4553.

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Introducing the

Rollstock Radial Crane

(Patent applied for)

A Two-Ton Crane in your workshop, working within two hours of delivery. No main structural alterations. Consult us if you have lifting problems. We give on the spot advice to solve your particular problems.

THE ROLLING STOCK & ENGINEERING CO.
ALBERT HILL, DARLINGTON

ASK US TO QUOTE YOU FOR STEEL FABRICATION, STRUCTURAL ENGINEERING, PROFILE BURNING, HOPPER MANUFACTURE, ETC., ETC.

Enter No. 1101 on reply card

NUMBERING on METAL

"LEDA" NUMBERING MACHINES

NUMBERING HEAD for METAL

Consecutive and Repeat actions

Power, Fly, Hand or Pneumatic Presses and similar equipment

It is used for marking Aircraft components with reference numbers, part and drawing numbers, date of manufacture, inspection mark for marking Shells, Bombs, Cartridges, Engine Parts, Motor Car, Motor Cycle, Cycle, Wireless, Electrical, Clock, Watch and other instrument parts in all materials. Checks Labels, Name Plates, Pigeon Rings, in fact, any article which requires an identification mark. Massed produced articles can only be satisfactorily identified by individual reference number.

W LETHABY & Co. LTD
LEDA HOUSE, 124-132 CLERKENWELL ROAD, LONDON, E.C.1
Telephone: Terminus 1104 (3 lines)

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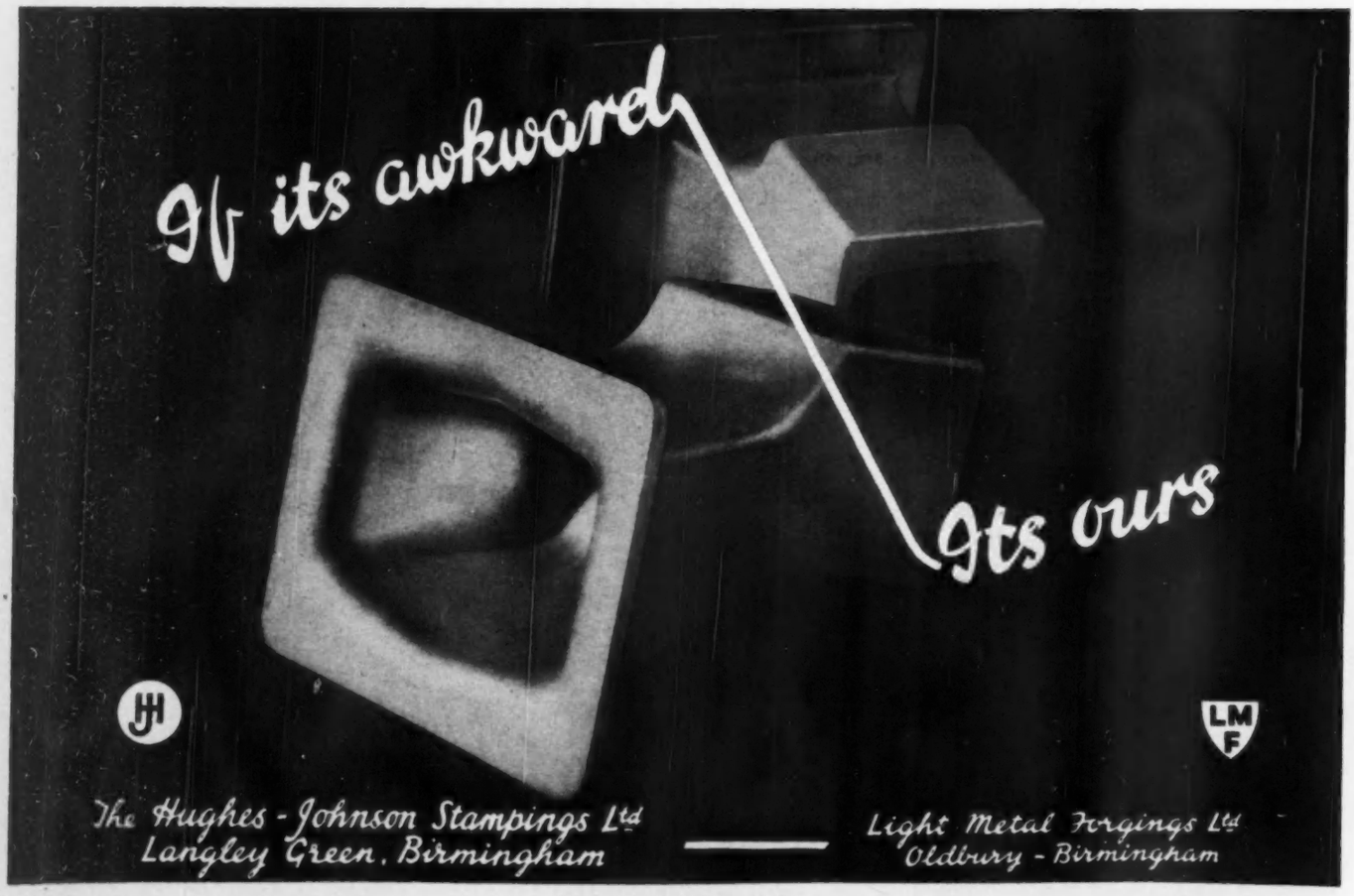

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CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-. **Inch Rate.** 48/- per single column inch and pro rata. 12 lines to 1 inch.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches) Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNIVERSITY OF SYDNEY

LECTURESHIPS

Applications are invited for the following positions in the Department of Electrical Engineering :

1. LECTURESHIP/SENIOR LECTURESHIP IN ELECTRICAL ENGINEERING. Candidates should have good academic qualifications in Electrical Engineering, experience in some aspect of power engineering, and a working knowledge of electronic techniques. The successful applicant will take part in teaching, primarily in the field of electrical machines, and in research.

2. LECTURESHIP/SENIOR LECTURESHIP IN ELECTRICAL ENGINEERING. Candidates should have good academic qualifications in Electrical Engineering or Physics, general experience in electronics and considerable detailed knowledge of solid state devices and circuits. The successful applicant will take part in the teaching of electronics and communication engineering, including fundamental aspects of solid state devices and circuits, and in research.

3. LECTURESHIP IN ELECTRICAL ENGINEERING. The successful applicant will be expected to assist in the planning and teaching of control system engineering at graduate and undergraduate levels and to pursue original research in this or an allied field. Extensive computing facilities are available, as well as a well-equipped control systems laboratory.

The salary for a Senior Lecturer is within the range £A2550 by £A95 to £A3000 per annum ; for a Lecturer within the range £A1730 by £A105 to £A2435 per annum. In each case cost of living adjustments will be allowed (at present £A29 p.a.). The salary is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant.

Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 31st January, 1961. E7191

UNIVERSITY COLLEGE OF THE WEST INDIES

APPOINTMENTS

Applications are invited for :

CHAIR OF ELECTRICAL ENGINEERING.
CHAIR OF CHEMICAL ENGINEERING.
SENIOR LECTURER OR LECTURER IN CIVIL ENGINEERING.
SENIOR LECTURER OR LECTURER IN MECHANICAL ENGINEERING.

Salary scales : Professor (revised salary including entertainment allowance) £2850 p.a. Senior Lecturer (under revision) : £1500 by £75 to £2250 p.a. Lecturer (under revision) : £1150 by £50 to £1450 by £75 to £1900 p.a. Child allowance. F.S.S.U. Unfurnished accommodation at rental not in excess of 10 per cent of basic salary. Passages for up to 5 persons on appointment, normal termination and study leave (once every 3 years). Detailed applications (6 copies), naming 3 referees by 31 December, 1960 to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained. E7211

WIGAN AND DISTRICT MINING AND TECHNICAL COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

ASSISTANT, GRADE "B"

Applications are invited for a post as ASSISTANT GRADE "B" in the Department of Mechanical Engineering. Duties will commence on 1st January, 1961, or as soon as possible thereafter.

Candidates should be graduates or hold equivalent professional qualifications, and have teaching or industrial experience.

Salary scale : £700 by £27 10s. (15) and by £37 10s. to £1150 per annum with additions for graduate status and training. Full allowance is given for relevant experience.

Further particulars and application form will be sent by the undersigned. Last date for the receipt of applications : Friday, 9th December, 1960.

E. C. SMITH,
Principal.

E7184

PUBLIC APPOINTMENTS

BOROUGH POLYTECHNIC

BOROUGH ROAD, LONDON, S.E.1

Principal : JAMES E. GARSIDE, M.Sc.Tech., Ph.D., F.R.I.C., F.I.M., F.Inst.F.

DEPARTMENT OF MECHANICAL ENGINEERING

HEAD OF THE DEPARTMENT

The Governors invite applications for the post of HEAD OF THE DEPARTMENT which becomes vacant on 1st January, 1961, when the present Head takes up an important industrial appointment.

Candidates should be University Graduates of good standing in Engineering and corporate members of an appropriate professional engineering institution, and have had suitable teaching and industrial experience. In view of the active research programme of the Department some experience—and preferably qualifications—in research are desirable.

Advanced courses of various types and "Sandwich" courses are at present being developed and it is intended that they will constitute an increasingly important part of the work of the Department.

The Department is at present a Grade IV department, the salary scale for which is £1988 to £2151 p.a.

Further particulars and Application Form obtainable from the undersigned.

FREDK. J. PACKER,
Clerk to the Governing Body.

E7203

MINISTRY OF LABOUR

GOVERNMENT TRAINING CENTRE, LETCHWORTH, HERTS

OXY-ACETYLENE WELDER INSTRUCTOR (UNESTABLISHED)

Ministry of Labour require an OXY-ACETYLENE WELDER for appointment as INSTRUCTOR (UNESTABLISHED) at Government Training Centre, Letchworth, Herts. Must be British subject, experienced and fully skilled, able to teach his trade and supervise the work and maintain control of trainees in his trade. Should have undergone training usual in this trade followed by at least five years' practical experience. Applicants should preferably possess O.N.C. or City and Guilds Certificate or equivalent qualifications where appropriate.

Selected applicants will be required to pass a Theoretical Test before appointment and a practical test of normal trade skills after taking up appointment. Prospect of eventual establishment. Commencing salary (at age 30 and over) £930 p.a., rising by two annual increments to £1000 p.a. Write for application form within seven days to Employment Exchange, Letchworth, Herts. E7210

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(FACULTY OF TECHNOLOGY IN THE UNIVERSITY OF MANCHESTER)

A LECTURESHIP IN MECHANICAL ENGINEERING

The Governing Body invites applications for A LECTURESHIP IN MECHANICAL ENGINEERING in the College, with corresponding title and status in the University of Manchester.

Candidates should have a major interest in Production Processes, particularly Metal Cutting, Metal Forming or Automatic Control. The successful candidate will be required to assist in the development and teaching of Courses on these topics and to undertake research for higher degrees. Salary, according to qualifications and experience, in the scale £1050 by £50 to £1400 by £75 to £1850 per annum. F.S.S.U. and family allowances.

Conditions of appointment and form of application may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1. The last day for the receipt of application is Saturday, 17th December, 1960. E7167

PUBLIC APPOINTMENTS

UNIVERSITY OF LIVERPOOL

DEMONSTRATOR IN THE DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for the post of DEMONSTRATOR IN THE DEPARTMENT OF MECHANICAL ENGINEERING. The salary will be within the range £650 to £750 per annum, according to age, qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of two referees, should be received not later than 30th November, 1960, by the Registrar, from whom further particulars of the conditions of appointment may be obtained. CV/Engr. E7164

LEE CONSERVANCY CATCHMENT BOARD

ENGINEERING ASSISTANT

Applications are invited for the appointment of an ENGINEERING ASSISTANT within the range of Grades A.P.T. I-II (£645 to £960 per annum, plus London Weighting) according to experience and qualification.

Applicants should have some experience in the design of Civil Engineering works, preferably connected with Land Drainage.

Travelling and subsistence allowance in force from time to time will be payable ; and the successful candidate may be required to provide his own car.

The appointment will be subject to the National Scheme of Conditions and Service for Local Authorities' Administrative, &c., Staffs, and to one month's notice on either side ; and the successful applicant may be required to pass a medical examination.

Applicants should state whether they would wish to be specified as contributory employees for the purposes of the Local Government Superannuation Act, 1937, and, if so, give particulars of previous contributory and non-contributory service.

Applications, stating age, qualifications, experience, &c., accompanied by copies of three recent testimonials, and endorsed "Engineering Assistant" should reach N. Medrington, Esq., A.M.I.C.E., M.I.W.E., Engineer to the Board, "The Grange," Crossbrook Street, Cheshunt, Herts, not later than first post on Friday, 23rd December, 1960.

J. L. SPILLER,
Clerk of the Board.

Head Office of the Board,
Brettenham House,
Lancaster Place,
Strand, London, W.C.2. E7202

CITY OF PLYMOUTH

DRAUGHTSMAN/SURVEYOR

Applications are invited for the position of DRAUGHTSMAN/SURVEYOR, Miscellaneous, Grade V (£685 to £760).

Applicants should be neat and quick draughtsmen with experience in carrying out surveys.

Age limit 40 (or 45 if already serving with a Local Authority).

The appointment is subject to medical examination and the successful applicant will be required to contribute to the Superannuation Fund.

Applications on forms obtainable from me are to be returned by the 12th December, 1960.

J. ACKROYD,
City Engineer and Surveyor.

The Guildhall,
Plymouth. E7197

EASTERN REGION OF NIGERIA

CIVIL ENGINEERS

Applications are invited for suitably qualified civil engineers to fill several vacancies in the Ministry of Works. Engineers are required who will specialise in either roads and bridges or in water supply.

Salary will depend on qualifications and experience and will be in the range, £1614 to £2166 a year.

Generous leave and allowances.

For details and conditions of appointment apply to the Recruitment Officer, Office of the Commissioner for Eastern Region of Nigeria, 9, Northumberland Avenue, London, E.C.2.

E7171

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

NORTH EASTERN AND YORKSHIRE REGION

THIRD ASSISTANT ENGINEER EFFICIENCY AND TESTING SECTION

Applicants are invited for the position of THIRD ASSISTANT ENGINEER in the Efficiency and Testing Section of the Generation Operation Department, Yorkshire Divisional Headquarters, Leeds.

Applicants should be educated to at least Higher National Certificate Standard in Mechanical Engineering and should have had experience of operation of modern power stations.

The successful applicant will be responsible for carrying out tests, investigations and efficiency studies on power station plant throughout the Division. He will be based at Skelton Grange Power Station but will be expected to travel in connection with his duties.

The salary for the appointment will be in accordance with the National Joint Board Agreement, Grade 6 BX, Schedule "B" (£1825 to £1610 per annum).

This is a re-advertisement and previous applicants need not re-apply.

Forms of application may be obtained from the Assistant Regional Secretary (Personnel), Central Electricity Generating Board, North Eastern and Yorkshire Region, 1 Whitehall Road, Leeds, 1, to whom they should be returned to arrive not later than the 9th December, 1960. E7183

THAMES VALLEY WATER BOARD

ENGINEERING ASSISTANTS

Applications are invited from suitably qualified persons for the following appointments :

A. ENGINEERING ASSISTANT : Salary, A.P.T. IV : £1140 to £1310.

B. ENGINEERING ASSISTANT : Salary—within the range of the special Grade for Engineering and Surveying Assistants : £840 to £1145, and A.P.T. IV : £1140 to £1310.

C. JUNIOR ENGINEERING ASSISTANT : Salary, A.P.T. I : £645 to £815.

Applicants for posts A and B should be Chartered Civil Engineers with some years of experience of water supply engineering.

Applicants for post C should have passed the intermediate, or equivalent, examination of the Institution of Civil Engineers or have completed professional training.

Appointments are subject to the National Scheme of Conditions of Service, the provisions of the Local Government Superannuation Acts, 1937–1953, and the passing of a medical examination.

Applications, stating age, qualifications and experience, together with the names and addresses of two referees should be sent to the Engineer and Manager, 16/20, The Forbury, Reading, not later than 10th December, 1960.

O. KEAN, M.I.C.E., M.I.Mech.E., M.I.W.E.
Engineer and Manager.

E7178

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

NATIONAL ENGINEERING LABORATORY, EAST KILBRIDE, GLASGOW

SENIOR EXPERIMENTAL OFFICER

SENIOR EXPERIMENTAL OFFICER : Department of Scientific and Industrial Research. Pensionable post at National Engineering Laboratory, East Kilbride, Glasgow, for man or woman at least 35 on 1st January, 1961, to lead and expand a team concerned with collecting and disseminating technical information required by the Laboratory's mechanical engineering research staff. Qualifications : normally a University degree in Engineering or a physical science, or equivalent. At least 5 years' responsible experience in an industrial or research library, and knowledge of information techniques, essential. Salary scale : £1410 to £1750. Starting pay may be above minimum. Promotion prospects. Housing available for married staff. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form quoting S/5230/60. Closing date 22nd December, 1960.

E7192

Classified Advts. continued on page 112

PUBLIC APPOINTMENTS

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for the R.A.F. at home and overseas as well as certain Civil Airports. Salary : £805 at 25 to £1095 at 34 or over thereafter rising to maximum £1260 with increase for London and slight decrease for country districts. Appointments long term with promotion and pension prospects. 5-day week with 4 weeks 2 days leave a year initially. Special allowances payable in addition to salary during overseas service.

Minimum qualifications and experience :

(i) (a) University degree or equiv. diploma in electrical and/or mechanical engineering with at least 2 years apprenticeship ;
or (b) Graduate or corporate member of I.E.E. with at least 3 years apprenticeship ;
or (c) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years apprenticeship.
and
(ii) have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.158/OA.

E6904

TENDERS

BIRMINGHAM TAME AND REA DISTRICT DRAINAGE BOARD

MINWORTH NEW WORKS

BACTERIA BEDS BLOCK "B" ELECTRICALLY DRIVEN ROPE HAULED RECTANGULAR SEWAGE DISTRIBUTORS

TENDERS are INVITED for the CONSTRUCTION and DELIVERY, SUPERVISION of ERECTION on foundations provided by the Board : commissioning and maintenance for a period of twelve months after the commissioning date of ELECTRICALLY DRIVEN ROPE HAULED DISTRIBUTORS sufficient in number to distribute sewage at maximum and minimum rates of 34·8 m.g.d. and 11·6 m.g.d. evenly over an area of approximately 6¼ acres. In addition the Tenderer is to include for the supply, laying and connection of all necessary cables from the Board's Central Substation adjacent to the block of beds.

Tender documents may be obtained from the Engineer to the Board, Rookery Park, Erdington, Birmingham, 24.

Tenders in the envelope provided must be delivered to the undersigned not later than first post on Monday, 13th February, 1961.

The Board is not bound to accept the lowest or any Tender.

ARTHUR J. WRIGHT,
Clerk to the Board.

Clerk's Office,
Lombard House,
Great Charles Street,
Birmingham, 3.

E7215

DUNMOW RURAL DISTRICT

CONTRACT NO. 15A

GREAT EASTON AND DUTON HILL SEWERAGE EXTENSIONS

TENDERS are invited on a FIXED PRICE Basis in accordance with the Ministry of Housing and Local Government Circular No. 31/57 for the CONSTRUCTION of SEWERAGE EXTENSIONS at Great Easton and Duton Hill (being completion of a contract started by a contractor who has gone into voluntary liquidation).

The sewerage comprises in all the laying of about 3000 lin. yards of 6in. diameter S.G.W. sewer, together with 4in. and 6in. diameter S.G.W. house connections, the construction of 7 brick manholes and 24 precast concrete manholes and ancillary works.

General Conditions of Contract, Specification, Bills of Quantities and drawings may be obtained from the Council's Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 67, Tufton Street, Westminster, S.W.1, on and after 21st November, 1960, on payment of a deposit of ten guineas, refundable only to Contractors who submit bona fide Tenders and return all documents and drawings. Deposit cheques should be made payable to Dunmow Rural District Council.

The Council do not bind themselves to accept the lowest or any Tender.

Tenders must be returned in envelopes which do not bear any name or mark indicating the sender, endorsed "Tender for Sewerage Contract No. 15A," and delivered at the office of the undersigned not later than 9 a.m. on 19th December, 1960.

F. A. RENNISON,
Clerk of the Council.

Dunmow Rural District Council,
Council Offices,
Duamow, Essex.

E7093

TENDERS

INDIA STORE DEPARTMENT

24003/60/HSK/HAL (2)

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

24003/60/HSK/HAL (2)
OIL-FIRED HYDRAULIC LIP POUR, TILTING TYPE CRUCIBLE FURNACE—for melting Aluminium. Capacity 350 lbs.

The Tender forms with schedules and specifications which are returnable on Thursday, 29th December, 1960, may be obtained from the above office (C.D.N. Branch) on payment of a fee of 10 shillings (not refundable) for each Tender.

The applications for Tenders should clearly state the above reference number.

E7195

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

IMPERIAL COLLEGE

A course of Eight lectures in :

MICROSCOPY

will be given on Tuesdays and Thursdays at 4 p.m., commencing 24th January, 1961, in the Technical Optics section.

A Practical course will follow commencing 20th February, 1961. Applications to the Registrar, Imperial College, S.W.7. E7172 E

CHESHIRE EDUCATION COMMITTEE

CHESHIRE COUNTY TRAINING COLLEGE, ALSAGER, STOKE-ON-TRENT

ONE-YEAR COURSE OF TEACHER TRAINING FOR CRAFTSMEN

Cheshire Local Education Authority, with the approval of the Ministry of Education, will provide at the above-named College from September, 1961, a one-year course designed to give skilled Craftsmen teacher training to enable them to take up posts as teachers of Handicrafts in Secondary Schools.

Applications are therefore invited for admission to this course from men who already possess appropriate qualifications, such as a Full Technological Certificate of the City and Guilds of London Institute, or a Higher National Certificate or Higher National Diploma, and who wish to be trained as teachers.

The particular academic requirements of individual students and the application of their craft skills to the needs of schools will be specially studied. The year of training will include periods of teaching in schools.

The basic salary for qualified Assistant Teachers is £520 per annum rising by annual increments of £27 10s. and one final increment of £40, to a maximum of £1000. Additional increments are given for approved qualifications and training. Account may also be taken of approved industrial experience acquired over the age of 21 up to a maximum of 12 increments.

Anyone needing further advice about the course, the qualifications required, the grants available to students while attending the course, and the teaching prospects available at the end of the course, should communicate with the Principal. Applications for admission to the course should also be made to the Principal. Early application is advised.

JOHN G. KELLETT,
Director of Education.

County Hall,
Chester.

E7209 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A MANUFACTURING GROUP supplying heavy equipment to industrial undertakings throughout the world require an ENGINEER aged 23 to 25 years for service with their Constructional Division. Applicants must hold a degree or equivalent in engineering and should be prepared to rough it on construction sites in order to obtain experience of construction methods and job administration. Some site experience with plant engineers or industrial undertakings and with a knowledge of surveying instruments is an advantage.—Applications in writing to the Personnel Manager, P.G. Engineering, Ltd., P.O. Box 21, Stockton-on-Tees. E7175 A

CHEMICAL AND MECHANICAL ENGINEER

Applications are invited from persons of executive standard who are capable of taking managerial responsibility at a high level.

The advertiser is a Scottish Engineering Company, designing and manufacturing Evaporating, Distilling and general Chemical Plants.

Technical qualifications, age and experience should be stated. The position offers good prospects and salary with generous life assurance and pensions scheme.—BOX No. E7165, "The Engineer."

A

SITUATIONS VACANT

CENTRAL ELECTRICITY GENERATING BOARD

EASTERN DIVISION

Applications are invited for the following appointment in the Generation Department (Construction Section) at Divisional Headquarters, Cockfosters, in North London.

SENIOR ASSISTANT ENGINEER (CONSTRUCTION)

Salary N.J.B., Class AX, Grade 1, Scale 17 : £1885 to £2145 p.a., inclusive of London Weighting.

The successful applicant will be required to carry out the co-ordination of Mechanical, Electrical and Construction Sections concerned with schemes ancillary to the Board's Generating Stations and other establishments.

The duties involve responsibility for Drawing Office services and for the design and engineering of complete projects up to £250,000 each, including the supervision of Staffs concerned.

Applicants should be corporate members of one or more of the Senior Engineering Institutions and have a broad experience in the construction and operation of Generating Stations.

Applications, quoting Reference S.V. No. 1409, stating age, qualifications, experience and present position should be sent to the Controller, Central Electricity Generating Board, Eastern Division, West Farm Place, Chalk Lane, Cockfosters, Barnet, Herts, to arrive not later than 3rd December, 1960.

E7187 A

CHIEF DRAUGHTSMAN. First class designer required for this post with firm of General Engineers in Bristol. Good knowledge of design of Pressure Vessels and stainless steel fabrications, with particular reference to the requirements of BS.1500. This will be a well paid position for the top class man. —BOX No. E199, "The Engineer." A

DEVELOPMENT AND DESIGN ENGINEER required, age 25-40 for expanding Company. Write giving age, experience, qualifications and salary required.—Written applications only to the Managing Director, John Darbyshire & Co., Ltd., Ripley, Derby. E3093 A

DEVELOPMENT ENGINEER required by an international company manufacturing a specialised product. Applicants should possess good all-round engineering qualifications and be in their early thirties. Ability to organise development work and management of staff. Post is in W. London until mid-1961 when it will be in N. Bucks. Salary at least £1000.—BOX No. E3091, "The Engineer." A

DIESEL SALES ENGINEER. Harland and Wolff require an Engineer with previous experience in sales of medium-sized Diesel Engine plant, and a knowledge of the market. Age between 28 and 35 with sound education and qualifications ; preferably a membership of an Engineering Institution. Salary, according to age, qualifications, and experience. There is a contributory pension scheme.—Apply in strict confidence in writing, stating age, experience, qualifications, and other details to 9, Whitehall, London, S.W.1. E7216 A

DEPUTY CHIEF MECHANICAL ENGINEER

required at the

EBBW VALE SECTION RICHARD THOMAS & BALDWINS LIMITED

Candidates should be between 35 and 50 years of age and should preferably have an engineering degree or be a corporate member of the Institution of Mechanical Engineers.

The duties will be to assist the Chief Mechanical Engineer in the overall supervision of all mechanical aspects of an Integrated Steelworks. These include Development, Steam Raising, Workshops, Stores and Maintenance.

Preference will be given to candidates with extensive experience in the maintenance of machinery associated with flat rolled products.

Salary commensurate with experience. Superannuation Scheme.

Application forms which should be returned by 13th December, are available from :

Chief Engineer,
Richard Thomas & Baldwins Limited,
Ebbw Vale Section, Ebbw Vale, Mon.

E7189 A

DEVELOPMENT ENGINEER

required by the United Kingdom Atomic Energy Authority, Production Group, Springfield Works, Salwick, Preston, Lancashire, to undertake development work and technical investigations into the application of modern engineering methods and equipment to production of nuclear fuel elements.

A recognised engineering apprenticeship and corporate membership of a senior engineering institution, or a good degree, are essential. Experience in the design or development of jigs, tools and mechanical handling equipment in light engineering production work is also required.

Salary : £860 (at age 25) to £1340 per annum, according to age, qualifications and experience.

Contributory Superannuation. Housing Assistance Schemes.

Send postcard for application form, quoting reference SF.78/J1, to Works Secretary at above address.

Closing date : 30th November, 1960. E7168 A

FIRST CLASS ENGINEER with experience of high velocity Air drying systems as applied to Paper and Board, to take up a position in the U.S.A. in a rapidly developing department of a well-known American Company. Excellent opportunities and prospects.—Apply with particulars age, experience, &c., to BOX No. E3092, "The Engineer." A

SITUATIONS VACANT

FIRM OF CHARTERED QUANTITY SURVEYORS require TAKERS OFF and WORKERS UP for large Civil Engineering and Building works in the Sheffield area. Positions offer scope for advancement.—Reply, stating age, experience and salary required to BOX No. E3072, "The Engineer." A

GLIKSTEN (WEST AFRICA) LTD.

Carpenters Road,
Stratford, London, E.15

require an

ASSISTANT ENGINEER (MECHANICAL)

for a permanent and pensionable appointment in Ghana. Candidates should be between 25 and 31 years of age, have served a recognised apprenticeship preferably in factory maintenance and have in addition a minimum of three years' practical experience.

They should also possess at least an Ordinary Certificate (Mechanical).

Please write with full particulars to :

The Personnel Officer.

E3084 A

LINGUIST required for technical work at Vickers-Armstrongs (Engineers) Ltd., Barrow-in-Furness. The language chiefly required is Spanish, but a good knowledge of French and German also would be an advantage. Applicants should submit precise information as to their qualifications in this field, together with the extent of their engineering technical knowledge, past experience, &c., to the Labour Manager at the above address. E7199 A

MECHANICAL ENGINEER, H.N.C. standard, required for non-destructive testing of materials and vessels. Specialised training will be given to successful candidate. Commencing salary £800 a year. Non-contributory pension.—BOX No. E7188, "The Engineer." A

MODERNISATION OF BRITISH RAILWAYS

THE WESTERN REGION

requires the following technical staff :

HEATING AND VENTILATION : SECTION HEAD.

The above permanent appointment is vacant, and experienced designers with A.M.I.H.V.E. are invited to apply. The successful candidate will be in charge of a section which is responsible for the design, specification and supervision of contracts to the value of £300,000 per annum. The work involves all forms of Heating, Ventilating, Water services, etc., and the man appointed must combine experience with a capacity for hard work, as well as possessing drive and initiative.

In return for these qualities we offer a job of great interest, a salary range of £1260 to £1490 per annum (at present under review), a pension scheme, and free and reduced travel facilities.

Applications, giving qualifications and experience to :

Chief Civil Engineer,
British Railways,
Western Region,
Paddington Station,
London, W.2.

E7169 A

VACANCIES EXIST AT PERA for ENGINEERS with wide experience of mechanical and production engineering and writing or editing ability. Duties consist of preparing and editing technical reports and articles. Good starting salary, pleasant working conditions and excellent prospects of advancement.—Send full details to the Secretary (I.772), Production Engineering Research Association, Melton Mowbray, Leics. E7200 A

WESTERN REGION OF BRITISH RAILWAYS requires :

ENGINEERING ASSISTANTS (capable of supervising Drawing Office staff) experienced in the design of reinforced concrete bridges and other structures to fill vacancies in posts in the salary range £1095 to £1150.

Interesting work in pleasant conditions with promotion on MERIT.

Superannuation Fund.

Reduced rates of Travel and other concessions.

Five-day week.

Applications, giving age, qualifications and experience, to :

Chief Civil Engineer,
British Railways,
Western Region,
Paddington Station,
London, W.2.

E7170 A

WORK STUDY ENGINEER. Thomas Potterton Ltd. (makers of gas- and oil-fired boilers and member of the De La Rue Group) are increasing their Work Study team and applications are invited from men with good Work Study experience and the right personality to develop with a Company that is in the forefront of an expanding industry. Salary dependent on age and experience. Excellent working conditions. Pension Scheme.—Apply in writing to Personnel Officer, Thomas Potterton Ltd., Emscote Road, Warwick. E3085 A

BOOKS and PUBLICATIONS

HMSO

Structural Frameworks for Single-Storey Factory Buildings

By H. V. APCAR

Several factors have a bearing on the problem of providing the most suitable structural framing for a factory building, and this study discusses the main types in relation to function and cost. **4s.** (*post 6d.*)

Fire Research, 1959

Illustrated report of research undertaken during 1959 into the outbreak, ignition and growth of fires, structural aspects of fires in buildings and their detection and extinction. **5s.** (*post 6d.*)

From the Government Bookshops or through any bookseller

HMSO

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A monthly journal for the professional electronics engineer.

It circulates to 86 different industries all over the world.

When electronic engineering is studied "Electronic Engineering" is read.

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Telephone: Central 6565

Published by Morgan Bros. (Publishers) Ltd.

Enter No. 1133 on reply card

SITUATIONS VACANT

PERA requires staff for research into machining operations, including the economics of machining, evaluation of cutting tool materials and cutting fluids, analyses of tool wear, studies of chip formation, development of new machining techniques, &c. Applications are invited from engineers, physicists, or metallurgists (preferably of degree or H.N.C. standard) interested in machining research. Ability to think analytically and write clear concise reports is essential. The conditions of employment are attractive and there are excellent opportunities for advancement. Commencing salary commensurate with experience and qualifications. Superannuation scheme. Removal expenses paid.—Full details, including present salary in confidence to the Secretary (R.773), Production Engineering Research Association, Melton Mowbray, Leics. E7201 A

WORKS MANAGER/DIRECTOR

A keen young engineer with first class knowledge of modern works management required by old-established expanding Public Company pre-eminent in hire car/P.S.V. operation. Factory employing 150 tradesmen situated in London. Applicants must have recent experience of similar position, involving fleet costing, budgetary control, &c. Starting salary £1500 p.a., pension scheme, &c.—BOX No. E3090, "The Engineer." A

SITUATIONS VACANT

HOOVER (Electric Motors) LIMITED

CAMBUSLANG, LANARKSHIRE

ENGINEERING DEPARTMENT

This expanding Department has two vacancies.

1. DRAUGHTSMAN: Applicants must have light engineering experience, and their work would be in connection with product drawings in a factory manufacturing f.h.p. motors and domestic products.
2. TECHNICAL ASSISTANT: Applicants should have Higher National Certificate or equivalent. Experience in f.h.p. motor or domestic product manufacture is desirable.

In addition to a progressive salary plan, the Company operates a generous pension and life insurance scheme, together with extended sickness pay.

Applicants should write to the Personnel Manager giving full details of age, previous experience and technical education.

E7198 A

THE MOND NICKEL COMPANY LIMITED

requires

for development work in the ferrous field

STEELMAKER - METALLURGIST

with full practical melting-shop experience in the production of alloy steels, preferably including the austenitic stainless types. University degree or equivalent advantageous. The successful candidate will be located in London, but his duties will include foreign travel. Pension and assurance schemes are in operation and, in appropriate cases, assistance can be given for housing.

Applications, which will be treated in confidence, should give details of age, qualifications, experience, salary required, etc. They should be addressed to The General Manager, Development and Research Dept., The Mond Nickel Company Ltd., Thames House, Millbank, London, S.W.1. Please mark envelope "Confidential D.33."

E7179 A

ICI

opportunities for

DRAUGHTSMEN

IMPERIAL CHEMICAL INDUSTRIES LIMITED

PLASTICS DIVISION

has vacancies for Draughtsmen at its headquarters at Welwyn Garden City.

The Plastics industry is expanding rapidly and to meet the Division's big development programme, which includes work on novel processes, there are openings for men with a Mechanical, Electrical or Instrument design background. Experience in work associated with process plant e.g. drying, powder conveying and packing, piping, heating and ventilating, would be an advantage and candidates should preferably hold at least an Ordinary National Certificate.

Good starting salaries will be paid and Pension and Profit Sharing schemes are in operation. For married men a temporary lodging allowance may be granted and assistance is given towards removal expenses.

Apply briefly, quoting reference No. 5055/A.O. to the Staff Manager,

Imperial Chemical Industries Limited, (Plastics Division)

Bessemer Road, Welwyn Garden City, Herts.

E7177 A

Classified Advts. continued on page 114

SITUATIONS VACANT

WORKS MANAGER

required

for Structural and Mechanical Engineering Repair Shops. This is a progressive appointment carrying a starting salary of not less than £1250 per annum.

Applications should be made in writing, stating age, qualifications and previous experience and addressed to

The Secretary,

JOHN YOUNG & CO. (KELVINHAUGH) LTD.,
120 KELVINHAUGH STREET, GLASGOW, C.3

E7182 A

SITUATIONS VACANT

DESIGN DRAUGHTSMEN

are required immediately for interesting work in new factory North of Glasgow.

Preference will be given to applicants with previous experience in Heat Exchanger and Airflow requirements. Good mechanical knowledge, apprenticeship and H.N.C. essential. Preferred age 25-35.

Good working conditions with excellent transport facilities. Superannuation Scheme.

Apply giving full details of education and previous experience to Chief Designer, Archd. Low & Sons Ltd., Kilsyth Road, Kirkintilloch, Scotland.

E7186 A

SITUATIONS VACANT

ALLIS-CHALMERS GREAT BRITAIN LIMITED

have the following vacancies for draughtsmen :—

1. **CHIEF DRAUGHTSMAN**

to take charge of Drawing Office, engaged on agricultural and earth moving machinery design.

2. **SENIOR MECHANICAL DRAUGHTSMEN**

preferably with experience of Tractor or heavy vehicle design.

These are well paid appointments offered by a progressive and expanding Company. The work is varied and interesting, and the factory is pleasantly situated in the country with free local transport provided by the Company.

Applicants should apply to
the Chief Engineer,
ALLIS-CHALMERS GREAT BRITAIN LIMITED,
Essendine, Nr. Stamford, Lincs.

E7196 A

CHIEF MECHANICAL ENGINEER

required by Medium Sized Engineering Company for their Llanelly Factory. To be Responsible to General Management for the design and development of the Company's products.

Applicants must be between the ages of 30/40 years and have thorough knowledge of general engineering principles and capable of basic design thinking. A good working knowledge of the design and installation of underground mining machinery would be an advantage.

Please apply in writing giving full details of qualifications, experience, present position held to General Manager, Crawley Industrial Products Limited, Llanelly, Carms.

E7194 A

SENIOR ELECTRICAL DESIGN DEVELOPMENT ENGINEER

A man of live personality required by a leading manufacturer of rotating electrical equipment to implement the expansion of the Development Department of a company situated in the Midlands.

Applicants will be judged on creative ability, leadership and capacity to progress in a live organisation.

Some years' design experience on A.C./D.C. rotating machines is required, backed up by a professional qualification or university degree ; a minimum attainment of H.N.C. may be acceptable.

This appointment carries a high commencing salary and opportunity for advancement.

A contributory pension scheme is in operation.

Applications, which will be treated in the strictest confidence, should contain full details of career and be sent to BOX No. E3087, " The Engineer. "

A

British Titan Products Co Ltd

has vacancies for

MECHANICAL ENGINEERS

at its Grimsby Factory

The Company is a very active and flourishing Chemical Industry of international standing and its continuing expansion offers plenty of interest and scope for Engineers on plant maintenance and construction, wherein the present vacancies occur.

Preference will be given to candidates with a University degree in Mechanical Engineering, but those with an equivalent professional qualification will also be considered. Post-graduate Apprenticeship is essential and the upper age limit for the appointments is 30.

Salaries and prospects are very attractive for men with the right qualifications. Annual Bonus Scheme and Non-Contributory Endowment Assurance and assistance for married men with house purchase and removal expenses.

Applications in strictest confidence to be addressed to :

THE PERSONNEL MANAGER,
BRITISH TITAN PRODUCTS COMPANY LIMITED,
BILLINGHAM, CO. DURHAM

quoting Ref. S.17

E196 A

DOWSETT HOLDINGS LIMITED

SMALL GAS TURBINES

REQUIRED
FOR A NEW PROJECT

Capable and qualified Engineer/Designer for the Development, Production and Application of gas turbine units from 50 to 500 b.h.p.

REQUIREMENTS :

(a) Age under 35.

(b) Engineering degree or equivalent.

(c) Knowledge of jet engines advantageous.

(d) Experience and ability in hydrodynamics a further advantage.

LOCATION :

Lincolnshire, with a move within 12 months to Lowestoft, Suffolk.

SALARY & CONDITIONS :

A liberal salary will be paid to the right man with excellent prospects for future promotion to positions of increasing responsibility as the project develops.

APPLICATIONS,

which will be treated in confidence, should give full personal particulars and details of past and present experience and present level of remuneration to :- The Managing Director, Dowsett Holdings Development Section, Tallington, Stamford, Lincs.

E7174 A

Important appointments for Research and Development

Due to commitments in The European Common Market area, the scope of work undertaken by the Mechanism Division of the Wilmot Breeden Laboratories is being broadened and offers interesting and varied appointments for qualified persons of proved ability. Vacancies exist for Senior Engineers and Designers, a Senior Production Engineer and an Experimental Designer. They will be members of a team directly associated with a research establishment developing accessory mechanisms for the U.K. and major European motor industries. Applicants should be prepared to make occasional journeys to the Continent. Working conditions at the Laboratories are excellent with transport available to and from the Establishment. Top salaries are offered to men with first class qualifications or experience in the appropriate fields, and there is a Staff Pension scheme in operation.

Senior Engineers
Graduates or persons with equivalent qualifications in Mechanical Engineering, Physics or Mathematics are required for work in this establishment which specialises in the Science of Mechanisms with particular reference to those used in the motor car. This involves work on Stress Analyses, Resonance and Body Vibration Phenomena, the Dynamic Behaviour of Body Structures and similar specialised projects. (Ref.: U/PI/1/E)

Senior Designers
Senior Designers who are genuinely interested in the evolution and development of mechanisms, and are capable of original thought in this field. (Ref.: U/PI/2/E)

Senior Production Engineer
An experienced Production Engineer is required to form and lead a team of specialists to engage in pre-production design of mechanisms.
Applicants must have wide experience of economic design for mass production methods associated primarily with light presswork as well as die-casting, plastic moulding or metal sintering processes. (Ref.: U/PI/3/E)

Experimental Engineer
An Experimental Engineer is required for work associated with the Research and Development of small mechanisms. He will be responsible for a small section concerning itself with the establishment of experimental procedures, design of test equipment, functional and endurance tests, etc.
Applicants should be of H.N.C. (Mechanical) standard or equivalent and have had experience in experimental work. (Ref.: U/PI/4/E)

Applications, which will be treated in strict confidence, giving full details of experience, age and qualifications, should be addressed to the Chief Development Engineer. The appropriate reference number should be quoted.

WILMOT BREEDEN LABORATORIES
Umberslade Park, Solihull, Warwickshire.

E7216 A

SITUATIONS VACANT

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for a company employing 1,500 in medium engineering, producing all parts of their product including motors and switchgear.

Duties : To be responsible to the General Manager for personnel and personnel matters including joint consultation, and for maintenance of plant, services, equipment and quality standards.

Requirements : Professional engineers with managerial experience at administrative level. Experience in the manufacture of machine tools and of heavy vehicle engineering would be most relevant. Preferred age 35 to 40 years.

Rewards : Initial salary at least £2,400. Pension scheme. Assistance with removal expenses and with house purchase. Please send brief details in confidence quoting reference G.2543 to D. C. Duncan.

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In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

E135 A

SITUATIONS VACANT

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required for

Beet Sugar Factory
in Iran

This is a completely new plant handling up to 500 tons per day.

Previous experience as Manager/Assistant Manager or Chief Engineer essential. Duties will include the responsibility for processing and also maintenance. The contract will be for an initial period of two years with a possibility of a further contract. Salary of up to £3,200 per annum depending on experience with generous allowances, including leave in the U.K. each year.

Please reply giving complete details and quoting Ref. No. K.7940 to BOX No. E7190, "The Engineer." A

SITUATIONS VACANT

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Anglo-Lautaro Nitrate Corporation, a large mining and chemical company with operations in the Northern part of Chile requires a graduate Mechanical Engineer (M.Sc. or B.Sc.) for a position in its Engineering Department.

The successful candidate will be expected to take charge of maintenance of mining equipment and plant machinery, maintain equipment records, control spare parts requisitions, perform equipment replacement studies associated with the production of sodium nitrate, potassium nitrate, iodine and boric acid.

Opportunities for advancement may be in either administrative or engineering directions.

Applicants should have experience in heavy equipment maintenance and should have demonstrated ability in initiating and directing maintenance in a large mine or chemical plant. Applications from recent graduates will also be considered.

The Company's operations are located near Antofagasta, Chile. It maintains complete machine shop, mechanical design and warehousing facilities.

Applications with full details of qualifications and experience, age and family status should be addressed to :—

Mr. C. S. Hill, Nitrate Corp. of Chile Ltd., Chile House, 20/24 Ropemaker St., London, E.C.2. E7214 A

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Light Engineering

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Candidates aged 36 to 45 must be time-served practical engineers, with up-to-date knowledge of welding and fabrication. They should have had time in a drawing office and essentially some experience of engineering management at least at assistant works manager level. Knowledge of aluminium founding, hydraulics or press work would carry weight. Please send brief details in confidence quoting reference G.3203 to H.C.S. Brand.

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17 Stratton Street, London, W.1.

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ICI **METALS DIVISION**

An

ELECTRICAL APPLICATIONS ENGINEER

is required for the Division Engineering Department of Imperial Chemical Industries Limited at WITTON, near Birmingham.

Responsibilities include the design, application and co-ordination of electrical installations in a variety of plants.

Candidates, preferably in the age range 30/35, with corporate membership of the Institution of Electrical Engineers, should have a degree in electrical engineering and wide experience in heavy electrical engineering, including the application and layout of electrical equipment, switchgear and control equipment.

This appointment is pensionable and the Company operates a Profit-Sharing Scheme. Assistance can be given towards house purchase and removal expenses for married men.

Please write for an application form to the Assistant Personnel Manager (Staff), IMPERIAL CHEMICAL INDUSTRIES, LIMITED, Metals Division, P.O. Box 216, Kynoch Works, WITTON, Birmingham, 6, quoting Eng/439/E.

E7130 A

The Pulsometer Engineering Co., Ltd.

CHIEF ENGINEER

for Reading

This is a senior Management appointment carrying direct responsibility to the General Manager for all engineering activities of the Company, including Drawing Office, Engineering Department and Design and Development.

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Applications giving full details of qualifications, training, experience, age and present salary should be addressed to the General Manager, **The Pulsometer Engineering Co., Ltd., Reading.**

E3094 A

OPPORTUNITY FOR YOUNG REFRIGERATION ENGINEER

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E7181 A

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Classified Advts. continued on page 116

SUB-CONTRACTING

KELLERING AND CAM PROFILING capacity up to 8ft by 6ft or 6ft diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4). E116 MW

MOBILE LIFTING SERVICE. Lump Sum or Hire Rate quoted for any lifting work by Lorry-Mounted or Crawler Cranes, any size, any area.—MOBILE LIFTING SERVICES LTD., A member of the TARMAC Group, Rotherham 78481. E187 MW

KELLERING AND COPY MILLING CAPACITY available up to 10ft. by 5ft.—British Federal Welder & Machine Co. Ltd., Castle Mill Works, Dudley, Worcs. Telephone: Dudley 54701. Thorpe Works, Egham, Surrey. Egham 3844. E7208 MW

YORKSHIRE ENGINEERING WORKS of medium size have facilities promptly available for machining and fitting complete machines, or machined and fitted units up to 2 tons, from customers drawings.—BOX No. E3088, "The Engineer." MW

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Broadheath, Manchester,

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E7193 MW

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THE PROPRIETOR of British Patent No. 756608, entitled "QUICK DETACHABLE PIPE COUPLERS" offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 140, So. Dearborn Street, Chicago, 3, Illinois, U.S.A. E6964 H

THE PROPRIETOR of British Patent No. 628891, entitled "ROTARY CRUSHING MILL" offers same for license or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern & Carlberg, 140 So. Dearborn Street, Chicago, 3, Illinois, U.S.A. E7204 H

THE PROPRIETOR of British Patent No. 712503 entitled "IMPROVEMENTS IN MACHINE FOR PRODUCING AND PACKAGING WIRE FORMS," offers same for license or otherwise to ensure its practial working in Great Britain.—Inquiries to Singer, Stern & Carlberg, Chrysler Building, New York 17, New York, U.S.A. E7205 H

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HOW OFTEN HAVE YOU WANTED PARTICULARS on an Industrial Product, your competitors perhaps?—Enquiries for such information addressed to INDUSTRIAL INFORMATION SERVICE, 28, Rivington Street, London, E.C.2, will be treated in strict confidence. E7207 O

ENGINEERING WORKS desire to purchase working drawings of proprietary machines, weight up to 2 tons, with a view to manufacturing and selling on their own account, or alternatively selling through a Sales Organisation in possession of drawings and who could place orders.—BOX No. E3089, "The Engineer." O

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E105 G

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DERRICK CRANES.—7-ton Henderson, 110ft. jib, electric, 1952; 7-ton Anderson Grice, 100ft. jib, electric; 1½-ton Anderson Grice, hand, 40ft. jib; 5-ton Butters Grabbing, 80ft. jib, electric.

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		Main Location	*Auctioneers*
November 29-December 1	**Vehicles, earth moving equipment, mobile cranes and motor cycles.**	W.D. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
December 13	**Machine tools and miscellaneous stores.** including: Denham, Pratt & Whitney, Southbend and other centre lathes; Ward No. 2A Denver No. 6R, Timbrell & Wright Nos. 2A and 3, Herbert Nos. 1, 3 and 4 capstan lathes; Gishalt No. 4 turret lathe, B.S.A. multi tool lathe, Scrivener rough turn lathes; Hepburn, Oldfield & Schofield & Braithwaite facing, boring and recessing lathes; Kitson, Sentinel, Mann and other "C" type hydraulic lathes; Norton, Landis & Newall cylindrical grinders; Orcutt internal and external gear grinders; Cincinnati No. 2 universal cutter grinder; Hunt twist drill sharpeners; Noble & Lund saw sharpener; Edgwick horizontal miller; Wadkin, Archdale 3ft. and Town 4ft. radial drills; Asquith 4ft. 9in. portable universal radial drill; Sciaky 75KVA and British Federal 50 and 100KVA seam welders; bench drills; grinders and polishing spindles; Sturtevant rotary dryers; overhead conveyor; sectional buildings; canteen and camp equipment; hand tools; generator sets; industrial trucks; M.T. Spares; scrap tyres; furniture; trailer mounted 150 c.m. searchlights; scrap batteries; paint; clothing and textiles including greatcoats; scrap blankets; canvas, webbing and groundsheets.	W.D. Storage Depot, South West Stores, Euxton Lane, Chorley, Lancs. (Sale at Cheetham Town Hall, Manchester 8.)	J. H. NORRIS & SON (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
1961 January 4	**Miscellaneous stores.**	Northern Command Ordnance Sub. Depot, Barlow, Nr. Selby, Yorks.	BARTLE & SON (Dept. L), 50-52 Merrion Street, Leeds, 2. (Tel.: 20898.)
January 11	**Machine tools and miscellaneous stores.**	Central Ordnance Depot, Tidworth. Central Ordnance Sub-Depot, Devizes. (Sale at Corn Exchange, Devizes.)	FARRANT, WIGHTMAN & PINNIGER (Dept. L), Market House, 2, Newport Street, Swindon. (Tel.: Swindon 5151/2.)
January 19	**Miscellaneous stores.**	W.D. Storage Depot, Rotherwas, Hereford.	RUSSELL, BALDWIN & BRIGHT LTD. (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)
January 27	**Miscellaneous stores.**	Command Ordnance Depot, "Coypool, Marsh Mills, Plymouth. (Sale at Kinterbury House.)	WOOLLAND SON & MANICO (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 69292.)

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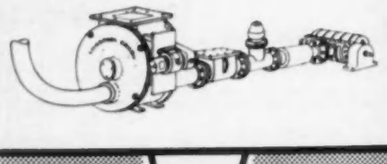

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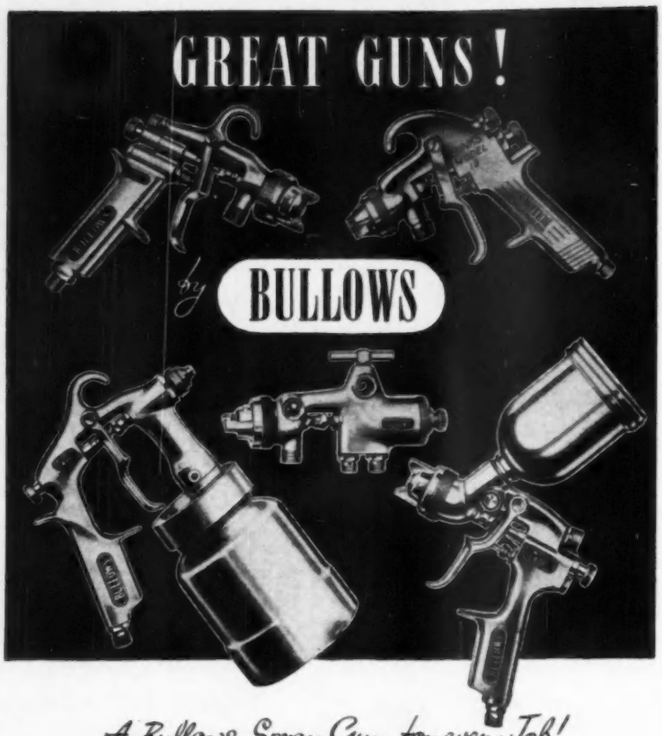

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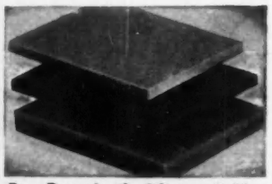

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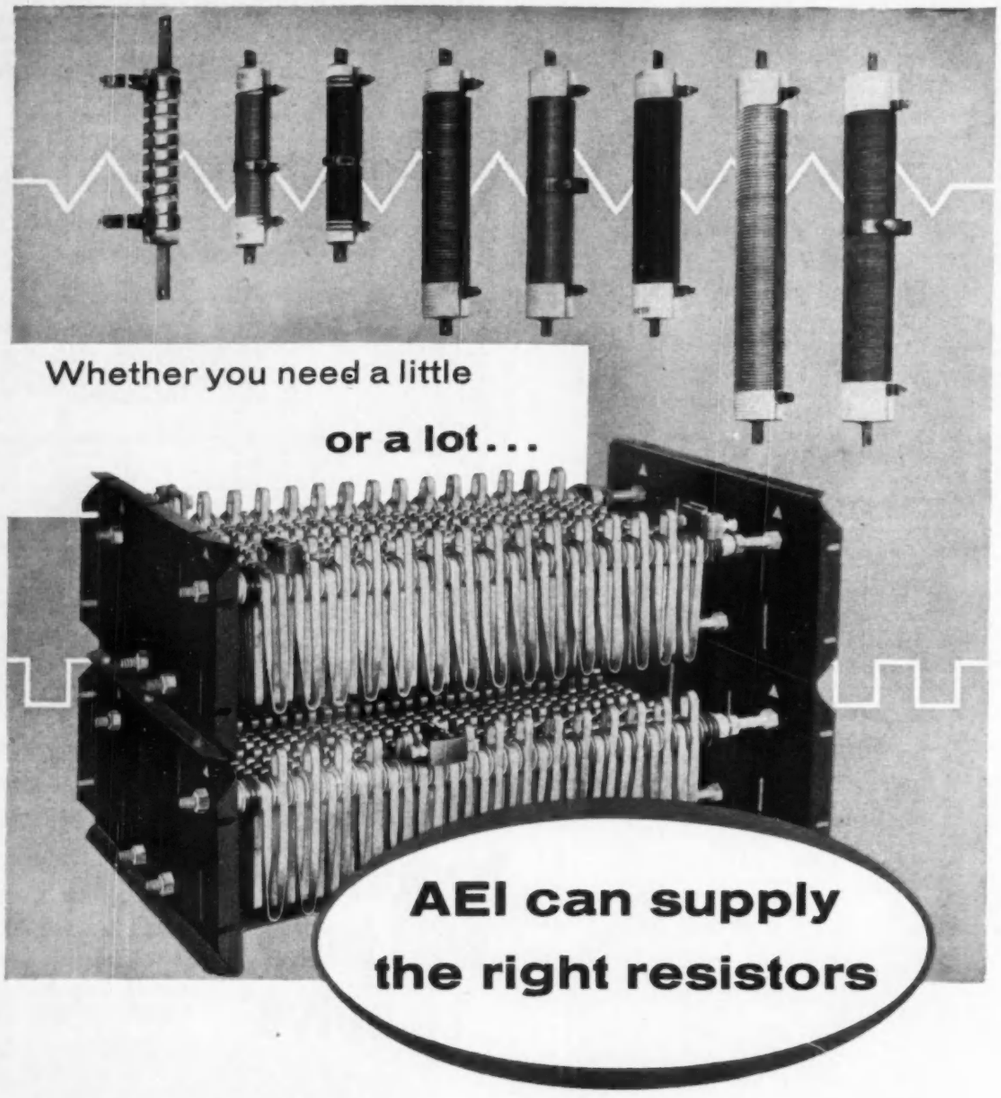

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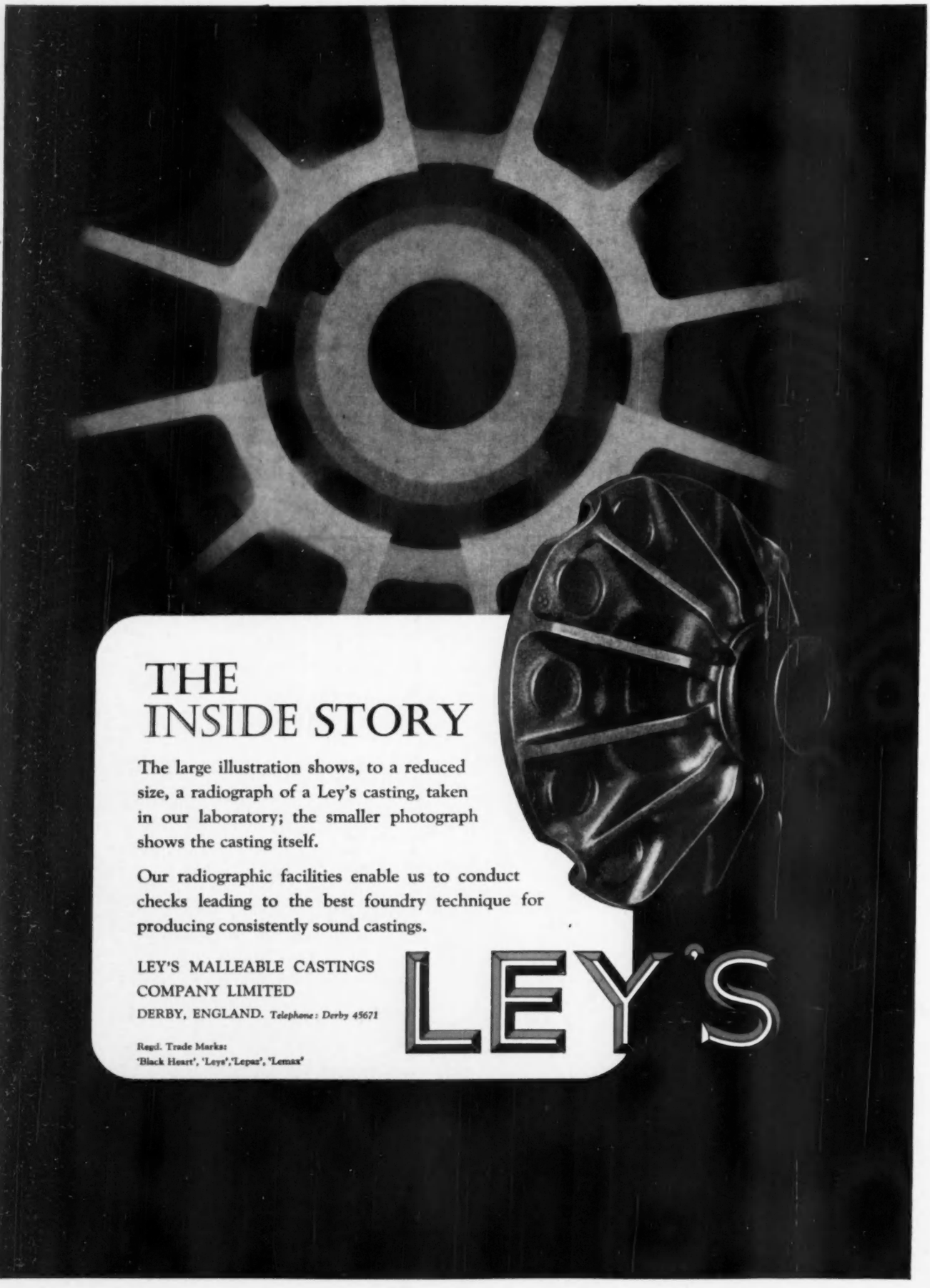
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